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INDUSTRIAL ORGANIZATION THEORY AND EXPERIMENTAL ECONOMICS

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INDUSTRIAL ORGANIZATION THEORY AND EXPERIMENTAL ECONOMICS

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The introduction of laboratory experimentation in economics was motivated by theories of industrial organization and performance. The first published market experiments were those of E. H. Chamberlin (1948). He explored the behavioral characteristics of markets he described as being "purely" but not "perfectly" competitive and he thought that the principles of monopolistic competition would be more useful than the textbook theory of demand and supply in explaining the observed behavior. Hoggatt (1959) focused on markets with three competitors and provided the first experimental evidence that the Cournot model might be a reasonably accurate description of behavior. Oligopoly and bilateral monopoly motivated the classic work of Fouraker and Siegel (1963) which introduced several of the techniques still used today.

The field of experimental economics has experienced substantial evolution during the intervening twenty-five years. Experimental techniques have become somewhat standardized. The art of posing questions, which make experiments relevant for the profession in general, has become refined. Many experiments have been conducted and uniformities of behavior are being recognized.

This paper is an attempt to provide an introduction to the methods and an assessment of available results which might be useful to students of industrial organization.

The paper has seven sections. Sections one and two address some methodological issues. Section one identifies the nature of questions answerable by experimentation in relation to the broad field of industrial organization. Section two outlines some of the step-by-step details of laboratory procedures.

Sections three through five summarize experimental results. In section three markets with several participants are analyzed and compared to a competitive model. Section four summarizes monopoly results. Section five, which is the largest, deals with oligopoly. This organization of the material is natural from the point of view of traditional theory. It is not necessarily natural from the point of view of results. As will become evident from the following pages, market institutions have a substantial influence on performance and this influence sometimes outweighs the importance of industrial concentration and relative firm size. Consequently, on occasion it is easier to organize and summarize results according to market institutions as opposed to numbers, size, or other economic parameters.

The sixth section outlines several common criticisms of experimental methods. The recent explosion of professional interest in experimental methods reflects, in part, a recognition that these and other traditional criticisms of experimental methods can be avoided by proper research designs and by placing proper qualifications on conclusions. The section deals directly with such problems.

I. EXPERIMENTAL ECONOMICS AND INDUSTRIAL ORGANIZATION

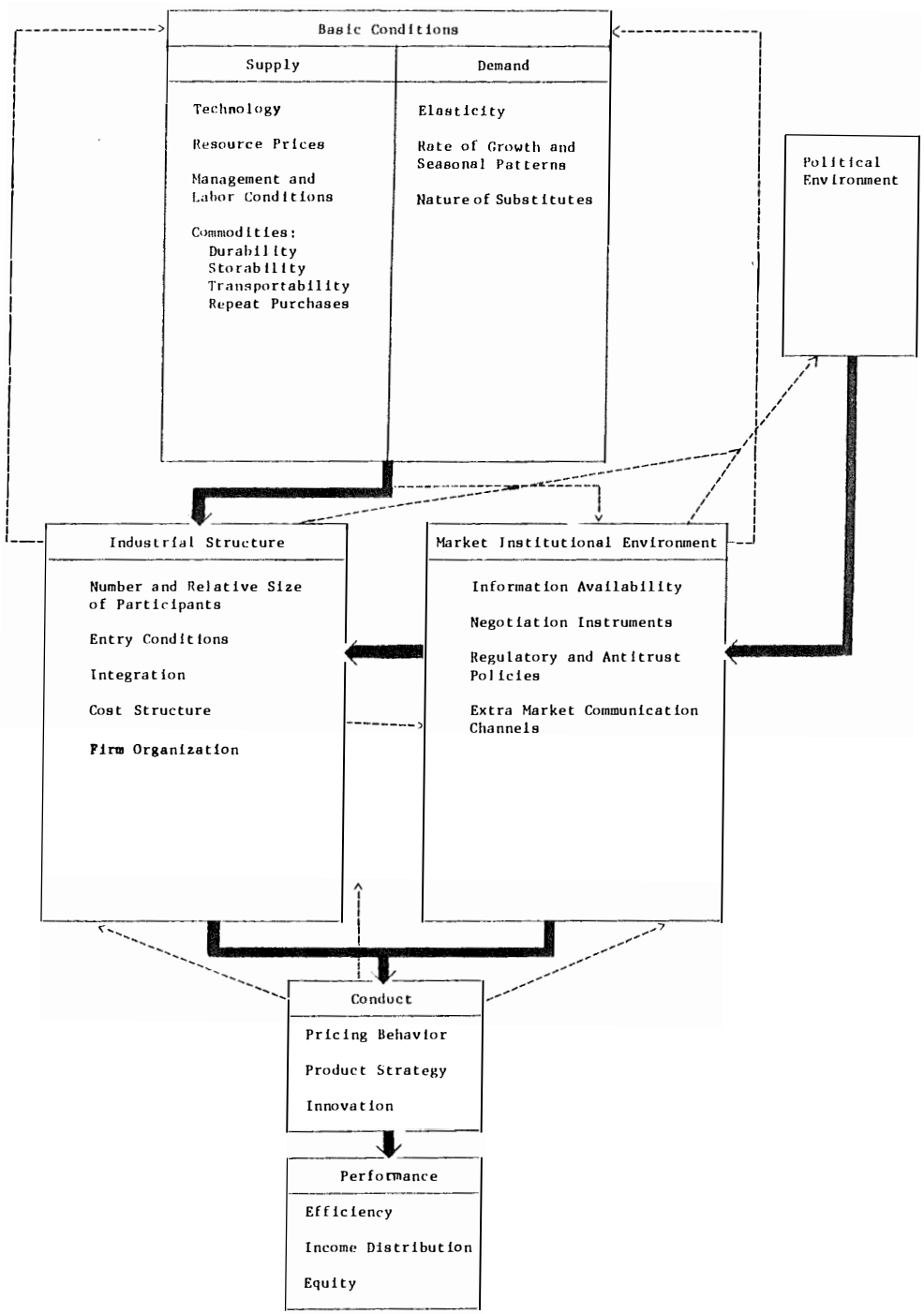
Experimental methods provide a source of shared experience for scholars who are developing and evaluating theories about complicated naturally occurring processes. While laboratory processes are simple in comparison to naturally occurring processes, they are real processes in the sense that real people participate for real and substantial profits and follow real rules in doing so. It is precisely because they are real that they are interesting. General theories must apply to special cases, so models believed to be applicable to complicated naturally occurring processes should certainly be expected to help explain what occurs in simple, special-case laboratory markets. Theories which do not apply to the special cases are not general theories and thus cannot be advocated as such.

Laboratory data become relevant to the extent that questions can be posed which make the study of special cases relevant. It may not be possible to learn about complicated processes directly by recreating them in a laboratory. General Motors, with all its size and institutional complexity, cannot be recreated many times for the convenience of those who wish to know what might have happened had one of its features been altered. Still, one might be able to learn something about competing models of a complicated process by gaining experience with their accuracy in simple cases. Circumstances in which models tend to be less reliable can be identified and, to the extent that the predictions of a model are accurate over a wide range of laboratory circumstances, one gains some confidence in their accuracy when applied to the more complicated, naturally occurring circumstances.

The special cases reviewed here are those which have been of importance to industrial organization theorists. Figure 1 helps place them in a proper context by showing diagrammatically how the experimental questions are related to those of more traditional concern. The flow of the theory and the methodological perspective is consistent with that developed by Scherer (1971, pp. 3-7). The diagram is taken from Scherer with a few changes imposed to highlight the particular links which experimentation has been used to explore. Variables which contribute to the nature of market demand, costs, the psychological makeup of consumers, production technology as dictated by the physical properties of the commodity and engineering and management knowledge, resource availability, etc. are listed in the category of "basic conditions." Traditional theory provides an analysis of how the basic conditions tend to influence industrial structure (the number and size of firms, cost structures, degree of integration, etc.). This influence is represented by the dark arrow. The theory then continues to explore how industrial structure when combined with principles of economic behavior dictate conduct and performance.

Within this framework the special cases explored with laboratory tools can best be identified by adding another category drawing variables from both the traditional conduct category and the basic conditions category. These variables are those which characterize the market institutional environment. They are the rules and organizational structures which govern pricing and purchase decisions. In some cases they might be identified as aspects of managerial style and thus placed in the basic conditions category. In other cases they may be identified as aspects of the general marketing strategies of firms and thus be listed as part of conduct (e.g., price posting).

FIGURE 1


Basic Conditions
Supply
Demand
Technology
Resource Prices
Management and Labor Conditions
Commodities:
Durability
Storability
Transportability
Repeat Purchases
Elasticity
Rate of Growth and Seasonal Patterns
Nature of Substitutes
Political Environment
Industrial Structure
Number and Relative Size of Participants
Entry Conditions
Integration
Cost Structure
Firm Organization
Market Institutional Environment
Information Availability
Negotiation Instruments
Regulatory and Antitrust Policies
Extra Market Communication Channels
Conduct
Pricing Behavior
Product Strategy
Innovation
Performance
Efficiency
Income Distribution
Equity

Still, in other cases they are dictated by sources external to the industry such as governmental regulatory policies or as in the case of the securities industry by the policies of another industry (e.g., the stock exchanges) which specializes in providing marketing services.

Five prominent forms of market institutions have been studied in the experimental literature: (a) auction markets, (b) posted bid (offer) markets, (c) negotiated price (telephone) markets, (d) markets with price protection and advance notice policies. A fifth, sealed bid (offer) markets, will also be briefly examined here as a special case of a single seller arrangement.

Actually, the listing of only five different types involves an oversimplification. Each of these types can be subdivided further into special types. Auction markets, for example, can be either English or Dutch according to whether the prices start low and are bid up by competition or start high and are reduced until some competitor accepts. English auctions can be "double oral" or "one sided." Markets differ according to whether or not the terms of contracts are public and the sequence in which bids, offers, and terms become known. The possibilities are so rich that it sometimes seems more appropriate to think in terms of a continuum rather than fixed classes. For example, posted price auctions look very similar to "sealed bid" auctions if sellers must post prices without the knowledge of other prices and without the ability to immediately "adjust" prices in light of the competition.

In addition to industrial structure and the market institutional environment, situations can differ according to the general information of participants. Agents may or may not be aware of the options or the

payoffs of others. There may also be differences about the knowledge about others' knowledge. So the reader can see that relative to what one would like to know, the number of studies covered below is modest indeed.

Laboratory studies have focused upon how industrial structure and market institutions influence conduct defined in terms of price patterns and resource allocation and also how the two categories influence performance defined in terms of income distribution and efficiency (the dark arrows). The link which has not yet been explored systematically is the influence of market structure on market institutional variables. No doubt in time this link will receive attention. Its importance is widely recognized but it does pose problems for experimental methods as discussed in the concluding section. Nevertheless, the reader should be aware of the limited scope of existing results so they can be placed in a proper context.

Because laboratory studies focus upon particular links, they are special cases for the general theories which explain all the interactions, feedbacks (as represented by the dotted lines in the Figure) and influences among all three groups of variables: industrial structure, market institutions, and conduct. Within the general theory certain types of industrial structures are thought to directly influence market institutions (cartel organizations, for example, are thought to be more likely in markets with few firms) and then the market institutions once developed induce feedback effects which operate to change the industrial structure (e.g., firm size). Thus, the theory is applied to explain how both types of variables will evolve and, while evolving,

will jointly influence market conduct. Experimental studies have tended to use this last link of the general theory as a guide to what to look for in the behavior of simple industries (relative to the naturally occurring industries). In most experimental work the basic conditions, the industrial structure, and the market institutions are all exogenously determined treatment variables. All are held constant while the resulting conduct is observed so the joint influences of industrial structure and market institutions on conduct and performance can be ascertained and understood in terms of the theories as applied to those circumstances.

II. LABORATORY MARKET DETAILS

The only way to fully understand how laboratory markets are conducted is by personally conducting several experiments under the supervision of an experienced experimentalist. It is easy to create a real market as described in the first paragraphs below. The difficult part is creating a market that demonstrates a point which will hold upon replication in other subject pools and by other experimenters. Because we know now that market behavior is sensitive to individual preferences and institutional arrangements, the experimenter must avoid contaminating these variables with poorly developed procedures. The second subsection covers some of the procedural details. The final paragraphs of the section elaborate on the measures used to evaluate the markets.

A. Market Creation

The key economic variables are individual preferences, the value individuals place on objects, and the form of the market organization within which buyers and sellers interact. Preferences are induced by a special application of derived demand theory called induced preference theory (Smith 1976b; Plott 1979). Buyers make money by buying from sellers and reselling to the experimenter according to a predetermined redemption value schedule. The difference between the purchase price and redemption value is profit which is the buyer's to keep. Sellers make a profit by purchasing units from the experimenter at a predetermined cost schedule and selling to the buyers. The difference is a profit which the seller keeps. In addition to these profits, participants frequently receive a small commission for each trade. The role of the commission will be explained below.

The idea is deceptively simple. If an individual prefers more money to less; if an individual has no attitude toward the commodity or situation other than the advantages created by potential resale; and, if the individual fully understands the terms of resale, then the redemption schedule is a limit price schedule for the individual. Figure 2 contains an example of what buyers typically see. The redemption value of the first unit this individual purchases during a period is in row one. The purchase price is entered in row two and the profit and profit plus commission are entered in rows three and four respectively. As can be seen, these entries are made for each purchase during a period.

Neglecting the commission for a moment, the incentives of

FIGURE 2

Redemption Values

Individual Buyer Number _____

Period _____

Unit	Row		Value
1	1	1st unit redemption value	$2.00
	2	purchase price	
	3	profit	
	4	profit + 15¢ commission	
2	5	2nd unit redemption value	$1.50
	6	purchase price	
	7	profit	
	8	profit + 15¢ commission	
3	9	3rd unit redemption value	$1.00
	10	purchase price	
	11	profit	
	12	profit + 15¢ commission	
4	13	4th unit redemption value	$ .75
	14	purchase price	
	15	profit	
	16	profit + 15¢ commission	
5	17	5th unit redemption value	$ .25
	18	purchase price	
	19	profit	
	20	profit + 15¢ commission	
		Total period earnings	

Costs

Individual Seller Number _____

Period _____

Unit	Row		Value
1	1	selling price	
	2	cost of 1st unit	$ .25
	3	profit	
	4	profit + 15¢ commission	
2	5	selling price	
	6	cost of 2nd unit	$ .75
	7	profit	
	8	profit + 15¢ commission	
3	9	selling price	
	10	cost of 3rd unit	$1.00
	11	profit	
	12	profit + 15¢ commission	
4	13	selling price	
	14	cost of 4th unit	$1.25
	15	profit	
	16	profit + 15¢ commission	
5	17	selling price	
	18	cost of 5th unit	$1.75
	19	profit	
	20	profit + 15¢ commission	
		Total period earnings	

individual i can be represented by a total revenue function $R^i(x_i)$ indicating the revenue generated by a quantity of purchases x_i. The magnitude $R^i(x_i) - R^i(x_i + 1)$, the redemption value for the $(x_i + 1)$th unit can be seen as a limit price function. It is negatively sloped as shown but of course the slope as well as the pattern of such redemption value functions across agents are parameters under the control of the experimenter. Under competitive assumptions this redemption value schedule is the individual's inverse demand schedule. Thus the experimenter, by varying these parameters, can control demand elasticity, concentration of buyers, and other magnitudes of economic interest.

Incentives of suppliers are induced in a similar manner. Again, reference to Figure 2 demonstrates the technique for a typical individual supplier. Row two contains the cost of the first unit sold. This cost is incurred at the time of the sale. When the sale is made, the seller enters the selling price in the first row and then calculates the profits and profit plus commission as directed by rows three and four. The profit from other sales made during this period are similarly calculated. Thus, individual i has a cost function $C^i(x_i)$, and the marginal cost, $C^i(x_i) - C^i(x_i + 1)$, has already been calculated for the individual as shown on the forms. These functions, the individual shapes, and the distribution of the cost functions across sellers, are controlled by the experimenter. Supply can be elastic or inelastic. Entry can be easy or difficult. The number of sellers can be large or small. All such parameters are subject to experimental control.

Whether an individual is shown the redemption value for all periods at one time or just for one period at a time differs according to the purpose of the experiment. In many cases the individual knows his/her own redemption values for all periods at the beginning of the experiment, but there are important exceptions. If individual costs or redemption values are changing each period, for example, these would be revealed one at a time just before a period began. In almost all experiments the individual knows only his/her redemption value and nothing about the redemption value of others.[1] The procedures and instructions are designed to keep this type of information private.

Commissions are not always used. It is known that individuals tend not to trade units unless there is some advantage for doing so. For example, individual buyers (sellers) will not buy (sell) units at a price equal to the redemption value (marginal cost) unless there is a small commission. The function of the commission is thus to induce marginal trades by overcoming what seems to be a small transactions cost (Plott and Smith, 1978). Subjects are instructed not to trade at prices which are above (below) redemption values, thus avoiding the problem of including the commission as part of the limit price. More recent experimentation has dropped the use of commission and avoided the "marginal trade" problem by adjusting the market parameters to allow for some gains from trade at the margin. Care must be exercized however. Model predictions are usually based on an implicit hypothesis that marginal trades will be made and sometimes can easily be rejected on the basis of data generated in markets without commissions.

At the top of Figure 2 you will notice a period indicator. Experimental markets are usually conducted over a series of periods or "trading days." The length of a period is normally from five to fifteen minutes depending upon the volume of activity anticipated. Unless the commodity has some explicit properties of an asset which has a life over time (Forsythe, Palfrey, Plott, forthcoming), each period is like an independent trading day with demands, supplies, profit potential, etc., independent of (but possibly identical with) those of previous periods. It is well established that trading patterns change as the market days are replicated. No good model of this change exists but, as will be demonstrated below, the market equilibration process occurs with the replication of market periods.

The market institutional organization has been an important treatment variable. The mechanics of how buyers and sellers get together can substantially influence the general market performance. That is, for the same underlying incentives, the market performance is affected by a change of institutions. For example, the original experiments by Chamberlin (1948) had the agents circulating in a room and privately negotiating price when a buyer or seller was contacted. In some of these markets, terms of trade were publicly displayed on the blackboard while in others they were not. This market behaves much differently than, say, an oral double auction in which all bids (offers) are orally tendered, publicly displayed with only one outstanding (the last, the best, etc.) bid (offer) open at any point in time. Sellers (buyers) are free to accept an outstanding bid (offer) by a public, verbal indication. Thus in the oral double

auction, all bids, offers, and contracts are public information, and this is not the case in the Chamberlin organizations.

B. Experimental Procedures

The experimental procedures are one of the most important aspects of an experiment but they can be easily overlooked. For example, the wording of the instructions and the format of the instructions in most experiments have evolved so that very little about them is arbitrary or has not been subjected to substantial scrutiny. The extreme care is dictated by two overriding concerns. First, the procedures must be formulated so that other researchers when following them will be able to replicate reported results. The heart of the experimental method is replication and the procedures embody the operational content of many of the parameters and experimental conditions which, if changed, may induce different results. If results are to replicate with different subject pools and different experimenters, then the procedures must be carefully considered. Secondly, there is an almost pervasive belief that experimenters will or can influence the behavior of subjects by subtle suggestion about what the experimenter wants to demonstrate. Whether this belief is well founded or not is open to question[2] but, regardless of the answer, the procedures must minimize the potential for such influences if the results are to be taken seriously by a large number of people.

In reviewing the sample instructions in the appendix, the reader will notice the absence of words like "competition," "maximizing," "collusion," "coalition," etc., or other words which might suggest to the subject some theory or expectation on the part of the experimenter.

The examples used to illustrate accounting conventions and profit computations are standard across many different experiments. In fact, attempts are made to maintain as much of the wording and examples across vastly different types of experiments (e.g., committees vs. markets) in order to minimize the latitude for theories which seek to explain the results of a particular experimental series in terms of the language used in the instructions for that series.

The procedures can differ according to the purposes of the experiment. For example, marginal values are displayed in Figure 2 as opposed to total values so subjects need not compute the former in making decisions. It was done for them. The individuals take tests at the end of the instruction period to see if he/she can read these tables as hypothesized. After each of the first several periods, each individual's accounting is checked to see if there is any misunderstanding about the reward structure. Questions about the mechanics of calculating profits are welcomed and answered fully and openly. Yet, if someone asks, "what am I supposed to do?" the experimenter rereads the relevant portion of the instructions: "the experimenters do not care whether or how you participate so long as you stay within the confines of the rules." Presumably, if the capacity of an individual to understand or recognize a reward structure was a variable to be studied as part of the market, then all of these procedures should possibly be changed but those particular variables were held constant for most of the experiments reviewed here.

Some of the procedures are adopted to allow individuals as much "independence" from the social situation as possible. Social

security numbers and names (both of which are used as receipts for the monetary payments) are collected after the experiment is over. Individuals are paid in private so others need never know their earnings. When individuals are obviously confused or are having difficulty with the instructions, efforts are made to avoid any embarrassment. The commodity is never given a name, or reference is never made to a "similar" type of natural situation in order to avoid giving some impression about how individuals are expected to act.

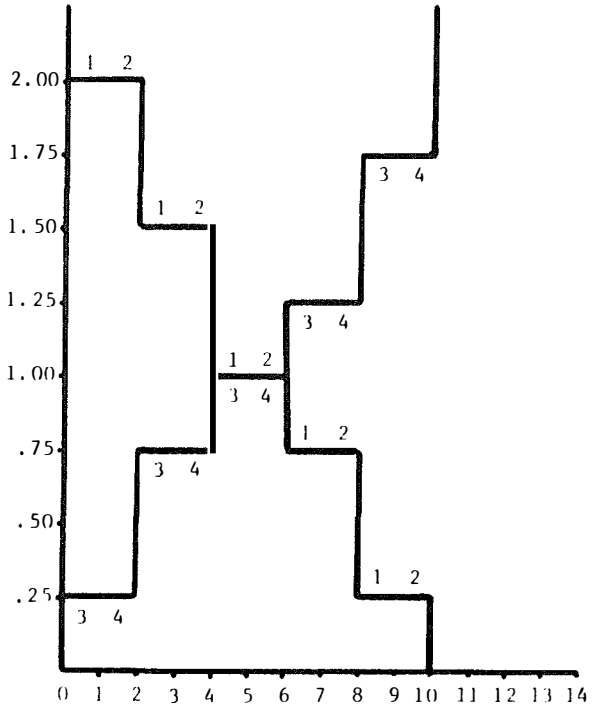
From a pragmatic point of view experimentalists realize that their experiments will be checked by other researchers. Such researchers may have a vested interest in having the results <u>not</u> replicate. This is especially true in fields like industrial organization in which the data can become part of an advisory process. An unambiguous and complete set of procedures is an important source of protection.

C. <u>Performance Measures</u>

Gains from exchange in most experiments are easily identified and measurable. Pareto optimal allocations are easily observable. In economics experiments the system attains an efficient allocation if and only if the subjects as a group maximize the total monetary payments from the experimenter. Thus, the relative efficiency of systems is determined by comparing the total payment to subjects with the maximum possible total payment.

In order to demonstrate how this measure of efficiency is related to ideas of consumers' plus producers' surplus, consider Figure 3. Assume the economy has two demanders and two suppliers. The demanders are identical and each has the redemption values shown in Figure 2. The

FIGURE 3



suppliers are also identical and each has the marginal cost schedule in Figure 2. The market demand function is obtained by adding the (inverted) individual limit price functions and the market supply is obtained by adding the (inverted) individual marginal cost functions. As can be seen consumer plus producer surplus is maximized at six units with each buyer (seller) buying (selling) three (three) units. A quick check indicates that this allocation also maximizes total subject profits from the experiment. If, for example, another unit was purchased, the subject payment to the experimenter (marginal cost) would exceed experimenter payment to the subjects (redemption value) on this unit. Total profits would thus be decreased.

This measure must be interpreted with some care. In some studies the commissions are included as part of the measure while in the other studies, they are not. Including them makes the measure sensitive to whether or not the marginal (zero profit) trades are made, thereby capturing one aspect of efficiency.[3] On the other hand, the commission seems to have no natural interpretation in the welfare economics model.

The efficiency measure is also sensitive to the shapes of the curves. Suppose, for example, the first unit redemption values are increased by a factor of ten and the first unit marginal costs are reduced to zero. Because these units will almost surely trade and they now constitute a large proportion of the surplus, the system efficiency would increase for any expected pattern of trading. Thus, by adjusting the level of the base profit potential with intramarginal units that will almost certainly trade, the absolute efficiency levels can be influenced.

A similar possibility exists with the allocation of redemption values across individuals. Suppose the two redemption values of $.75 were held by a third and fourth individual who have the right to buy only the one unit. If either of these two individuals make a trade, efficiency drops. Since they have only one (inefficient) unit to trade, they stand ready to trade and will trade should the price ever "wander" down in that range. These units seem to have more opportunity to be traded than when they are held as the fourth unit by the original two traders. In the latter case, inefficient trading can occur only if the price wanders low enough after an individual has traded three units.

Other special problems with efficiency measures occur in the case of uncertainty. Since those experiments have only a limited relevance to the industrial organization literature, they will not be reviewed here (see Plott and Sunder, forthcoming). The important point is that comparisons of efficiencies across markets with different economic parameters must be treated with care. If the underlying economic parameters are held constant and the institutions alone are changed, the efficiency comparison seems to have a solid base.

III. COMPETITIVE MARKET MODELS

A. Auction Markets

The competitive model seems to work the best when markets are organized as oral double auctions. Oral auction markets are characterized by public bids (offers) to buy (sell) units and the freedom of any participant to accept terms which (s)he wishes. Several variants exist depending upon the length of time or circumstances under which a bid (offer) remains outstanding, whether the bid (offer)

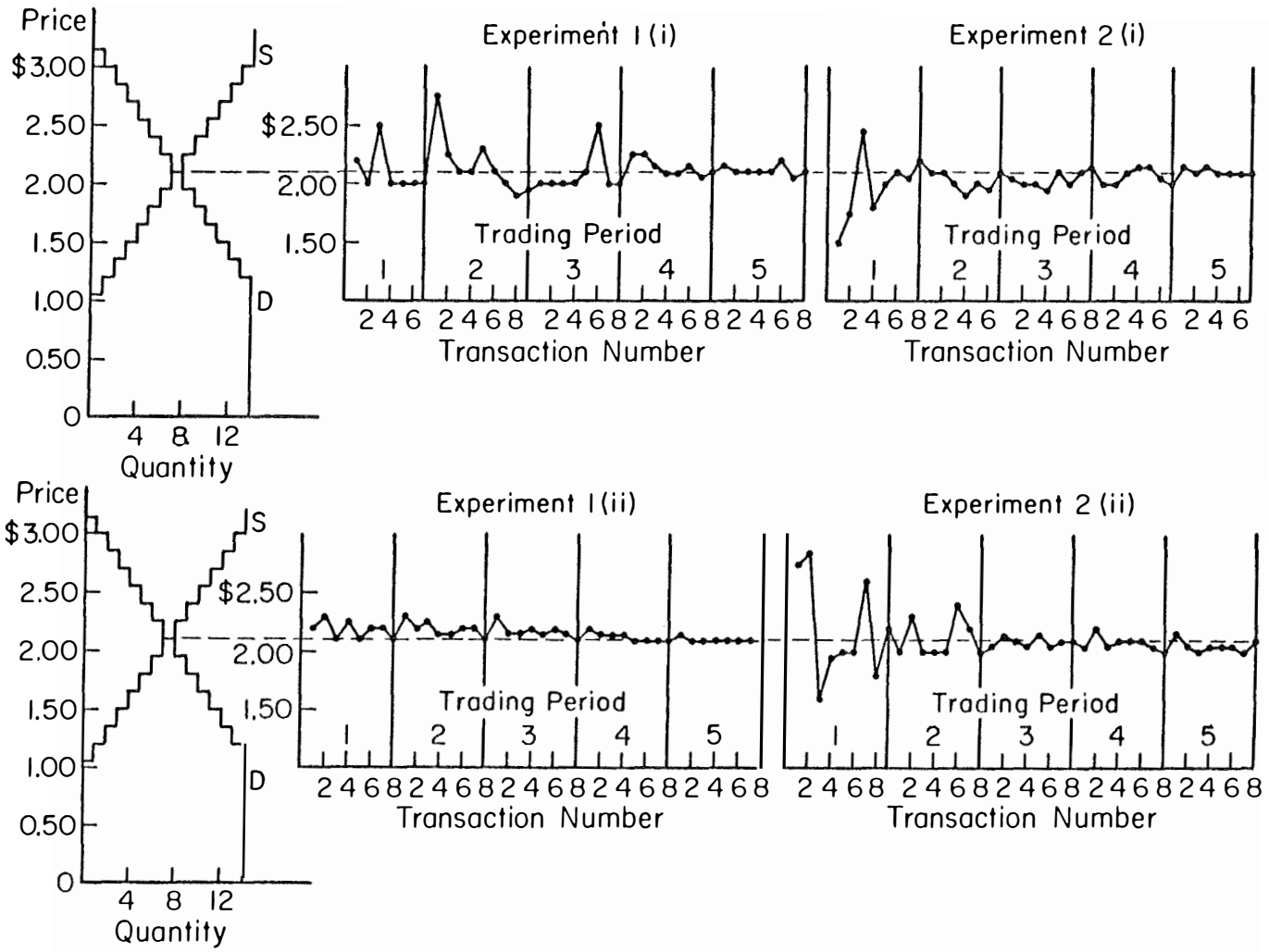
is made orally or logged through a computer, the roll of the specialist's "book," etc.

The overwhelming result is that these markets converge to the competitive equilibrium even with very few traders. Figure 4 is typical of the time pattern of prices. Shown there is the price of every sale in the order in which it occurred. Each period represents a market day with a given demand and supply. The competitive equilibrium is $2 with a volume per period of eight contracts. As market days are replicated under identical conditions, prices tend to converge to the competitive equilibrium. Efficiency levels tend to converge to near 100 percent. If a change in parameters had occurred, such as a shift in demand or in supply, the prices would have converged to the new equilibrium after two or three periods.

As long as the industrial structure has a few buyers and sellers, these convergence and efficiency properties appear to be independent of the basic economic conditions. Different shapes of demands and supplies as were systematically examined by Smith (1962, 1965, 1976a) yield no substantial differences. The variations explored covered various cases of demand elasticity and nonlinearity. In Smith (1965) a completely inelastic (in the relevant range) demand was used along with a fixed supply (greater than the quantity demanded). In all cases, after a few periods, the market performance was close to that predicted by the competitive model.

Other aspects of the basic economic conditions have been changed to allow for seasonality (Miller, Plott, and Smith 1977; A. W. Williams 1979; Hoffman and Plott 1981), middlemen (Plott and Uhl 1981),[4] and other features having to do with the time dimension

FIGURE 4



Source: Smith, Vernon L. "Bidding and Auctioning Institutions: Experimental Results." In Bidding and Auctioning for Procurement and Allocation, edited by Y. Amihud. New York: New York University Press, 1976a).

of a commodity life. In all cases the competitive model is an accurate predictor of market behavior. The model, when assets are involved, must be altered to accommodate rational expectations (Forsythe, Palfrey, and Plott, forthcoming) and inside information as to asset returns (Plott and Sunder, forthcoming). Plott and Wilde (forthcoming) and Plott and Sunder both involved uncertainty. Plott and Wilde; Forsythe, Palfrey and Plott; and Grether, Isaac, and Plott (1981) also involved multiple, interdependent markets. Still the empirical generalization is that with oral double auctions the competitive model is an accurate predictor under all perturbations of the basic economic conditions even though only three or four sellers and/or buyers may be involved.

Basic economic conditions do seem to influence the direction of convergence to equilibrium and thus the distribution of income and profit. The path to equilibrium seems to be from above (below) if consumer's (producer's) surplus is greater than producer's (consumer's) surplus. Thus, one might expect that markets with relatively steep demands and reasonably flat supplies record somewhat elevated profits for the sellers relative to the competitive equilibrium. These profits would accrue at disequilibrium trades and so the phenomenon would also be accompanied by falling prices. If the industry has been characterized by unanticipated demand or supply shifts, prices and profits can be affected. Adjustment to new equilibriums takes time and profits or losses can certainly reflect disequilibrium trades. To date only one study has attempted to characterize the dynamic adjustment path (Smith 1965) and the conclusions from this are clouded (Nelson 1980). No good theory of adjustment exists and experimental studies have not

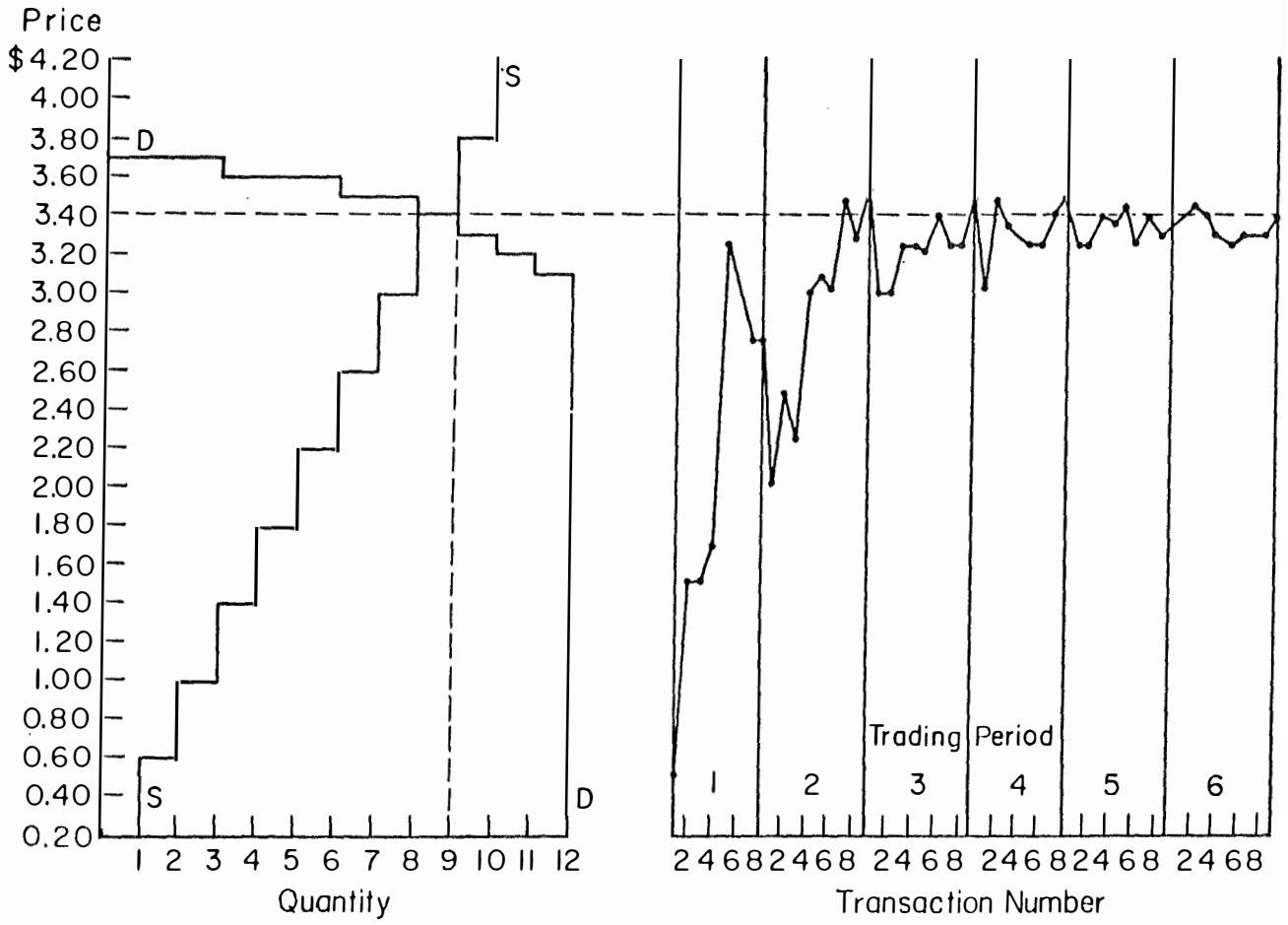
yet explored the influence of basic economic conditions on adjustment paths sufficiently to provide any further generalizations.

Figure 5 has been added to show a typical adjustment path for an oral double auction when producer's surplus is greater than consumer's surplus. The path is from below as predicted. If the relative surpluses were reversed, the approach, according to currently accepted hypotheses, would be from above. The key parameter is the surpluses, however, and not demand or supply slopes, although in the case of linear functions these are obviously closely related.

Changes in the market institutions are known to influence price and profit patterns. Double auctions conducted by computer can affect the speed of convergence especially with inexperienced participants (A. W. Williams 1980). For single unit auctions differences are exhibited between the Dutch auction, English auction, and second price auction. Theoretically (Nash bidding hypothesis) the English and second price auction should yield the same revenue while the Dutch, assuming some risk aversion, should yield more than both. The fact is, however, that the Dutch auction yields amounts less than or equal to the other two (Coppinger, Smith and Titus 1980). The Dutch auction also yielded less revenue than the first price auction which is theoretically similar.

The most dramatic difference within the class of oral auction institutions occurs with the one sided auctions. The approach to equilibrium is from above (below) if the auction is a one-sided bid (offer) auction. That is, if buyers (sellers) can bid (offer) while sellers (buyers) must accept or reject without making counter offers (bids), then the approach is from above (below). The distribution of income

FIGURE 5



Source: Smith, Vernon. "Bidding and Auctioning Institutions: Experimental Results." In Bidding and Auctioning for Procurement and Allocation, edited by Y. Amihud. New York: New York University Press, 1976.

is against the side which articulates the terms (Smith 1964; Plott, Smith 1978). Exactly why this occurs is not known but some sort of "counterspeculation" seems to be occurring. The "accepting" side of the market seems to anticipate as a group the potential for increased (decreased) prices as buyers (sellers) bid (offer) in competition among themselves. Even though a precise theoretical model does not exist, notice the implication of the result. Sellers who face an oral auction institution would prefer that the buyers bid. To the extent sellers can organize themselves to compete by accepting favorable bids and not making counter offers, the approach to equilibrium and thus profits will be influenced in their favor. Similarly, markets organized as oral offer markets may have some use as tools to counteract "unjustified market power" of sellers. It is important to note, however, that the nonmonopolized one sided oral auctions examined to date have all been nearly 100 percent efficient. The institution affects only the distribution of income.

The importance of industrial structure has not been systematically explored. For one reason the results under the oral auction institutions appear to be almost independent of industrial structure. Experiments with three and four sellers converge with regularity to the competitive equilibrium. If influences from industrial structure exist for nonmonopolized markets under the oral double auction, they are not so pronounced as to be clearly detectable in a large and varied data set.

B. Negotiated Prices

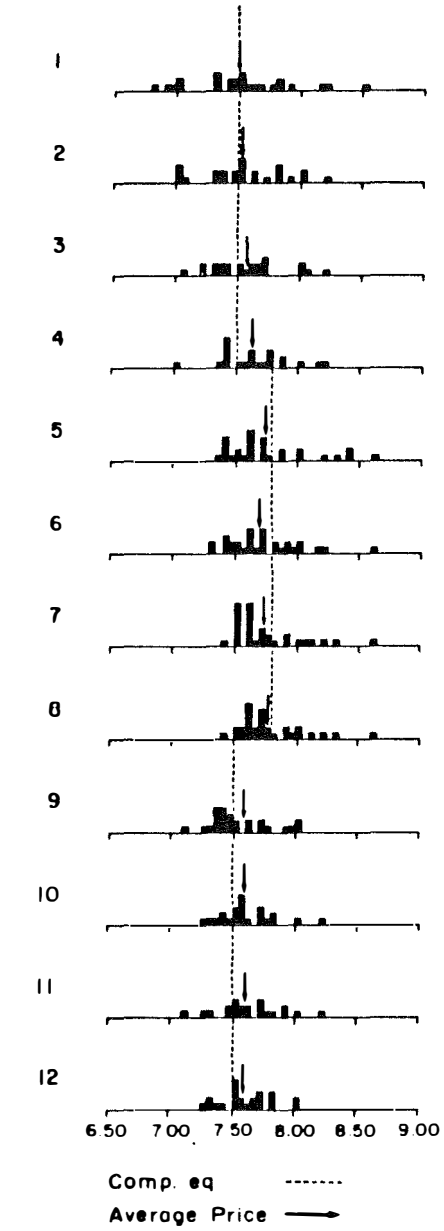
Negotiated price market institutions are those within which the terms of trade are privately negotiated with each transaction. Experimentally these conditions have been implemented through a telephone system where buyers and sellers, each located in a private office, negotiate privately by telephone. Buyers can call sellers and vice versa and discuss terms and/or agree on a contract price. Contact among buyers or among sellers is usually prevented. Consequently in these markets information about prices is not public. Buyers can shop among sellers and shopping costs are low (in some experiments advertising is permitted) but shopping and negotiating are the only sources of information.

The first experiments of this kind were done by Hong and Plott (1977). The distribution of prices from one such experiment is shown in Figure 6. As can be seen, the system begins with a high variance. Evidently some buyers are just better negotiators than others but the source of this (dis)advantage, whether they shop more (less), make more (less) credible promises or threats, etc., is unknown.

With time the variance shrinks. The mean price approaches the competitive equilibrium. When demand shifts (periods 5 and 9) the prices approach the new equilibrium. Efficiency in these markets is in the 80 percent and 90 percent range as is shown on the figure. Volume in the Hong and Plott experiments remains above the competitive-equilibrium volume. This result when combined with those of Chamberlin (1948) suggests that poor information may result in above competitive-equilibrium volume.

Only two different industrial structures have been explored

FIGURE 6



Period	Price			Volume		Efficiency
	Competitive Equilibrium	Actual Average	Standard Deviation	Competitive Equilibrium	Actual	
1	7.50	7.51	.416	21	25	83.0%
2	7.50	7.53	.332	21	24	88.9%
3	7.50	7.57	.296	21	23	90.1%
4	7.50	7.63	.280	21	22	89.2%
5	7.80	7.75	.347	27	28	87.7%
6	7.80	7.71	.293	27	30	87.3%
7	7.80	7.74	.281	27	30	90.1%
8	7.80	7.77	.265	27	30	95.8%
9	7.50	7.59	.210	21	23	96.2%
10	7.50	7.60	.226	21	23	95.8%
11	7.50	7.61	.253	21	22	94.8%
12	7.50	7.59	.206	21	23	94.3%

within this market institution. The Hong and Plott study had eleven buyers of about equal size. The twenty-two sellers, however, ranged from very large (the five largest firms had 60 percent of the market) to very small sellers, some of whom should not exist according to the competitive model because their costs were above the competitive equilibrium price. As is implicit in the price time series, the competitive model is reasonably accurate. The exceptions were the marginal sellers who were able to exist by selling at prices above the competitive equilibrium prices to (evidently) poorly informed buyers or those who did not care to shop.

The second study is by Grether and Plott (1981) who studied telephone markets with two large sellers (35 percent each) and two small sellers (15 percent each). Sellers in the experiment even had accurate knowledge of the market demand functions. The average prices as shown for all periods on Figure 7 are typical of the general results. Similar to the Hong and Plott results, prices start with a high variance. With time, variance is reduced and the competitive equilibrium is approached.

C. Posted Prices

Posted price institutions are those in which all prices are public and no discounts are made from the posted prices. Furthermore, posted prices are changed only after some period of advanced registration. In experimental markets the institution is implemented as follows. The posting agents decide between market periods what the price is to post next period. Each agent makes the pricing decision in private and submits the price to the experimenter. After collecting the prices the experimenter

announces all prices and the market opens. No price changes from posted prices are allowed during a period.

The posted price institution has received more scholarly attention than any other. Frequently, however, those conducting the research did not view themselves as engaged in a comparative institutional analysis. The original duopoly experiments of Hoggatt (1959) and of Fouraker and Siegel (1963) can be interpreted as having utilized the posted price institution. Almost all "market games" and "prisoner's dilemma" experiments can be interpreted as having posted prices. Nevertheless, it was not until 1978 (Plott and Smith) that it became recognized that the posted price institution has its own independent effects.

Two generalizations seem possible at this time. The most significant generalization is that posted offer (bid) markets tend to have higher (lower) prices than do oral double auction markets. This is higher (lower) in that the adjustment to equilibrium tends to be from above (below) and the convergence is slower if, indeed, the posted prices are to converge at all. Secondly, efficiency tends to be lower under the posted price institutions than under the oral double auctions.

These tendencies were first observable in experiments run by F. Williams (1973) who incorrectly thought they were due to the fact that his traders could buy or sell more than one unit. Previous experiments were oral auctions in which each trade had control of only one unit. Williams was interested in traders who controlled multiple units but in moving from one type of incentive to the other

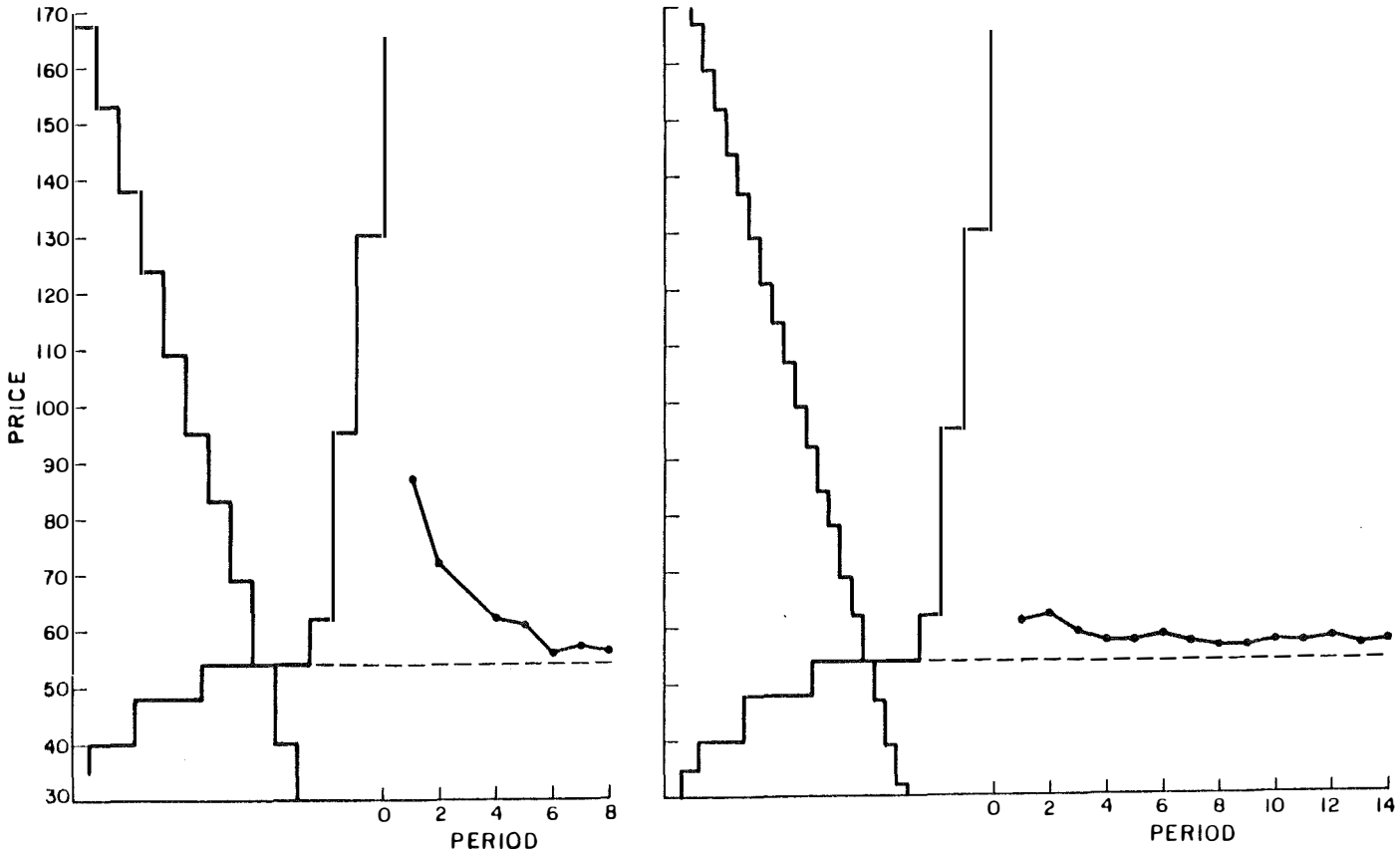


FIGURE 7

AVERAGE PRICE PER PERIOD
FOR ALL PERIODS IN TWO MARKETS

he also changed the institution. The results of two of his experiments are shown in Figure 8. These show the cumulative volume of trades at each price (e.g., the curve indicates the number of trades at price P or above). Prices at first are removed from equilibrium which is $.60, but with time they converge closely to it. Whether or not posted price markets ever stabilize at the competitive equilibrium is an open question. Certainly this does not occur within the number of periods characteristically necessary for oral auctions.

The Williams results were replicated by Plott and Smith (1978) who also demonstrated that the market institution and not multiple units is the cause. The possible importance of basic market conditions and industrial structure under posted prices is investigated in Hoffman and Plott (1981) and Hong and Plott (1977). In the former posted prices in markets with storage and speculation were studied. In the latter study thirty-three sellers were involved as opposed to the four in all other experiments. The two generalizations were observed to hold in all cases.

The Plott and Smith experiments and many subsequent experiments used people as buyers who could withhold purchases and play favorites to encourage low prices. The Williams experiment on the other hand utilized a computer in some sessions to simulate demanders according to the following strategy: first, purchase from the low priced seller all s(he) wished to sell and then move to the next low priced seller, continuing until excess demand does not exist. One of the principal discoveries of Plott and Smith was that their demanders behaved passively (or purely competitively) almost exactly like the Williams computer.

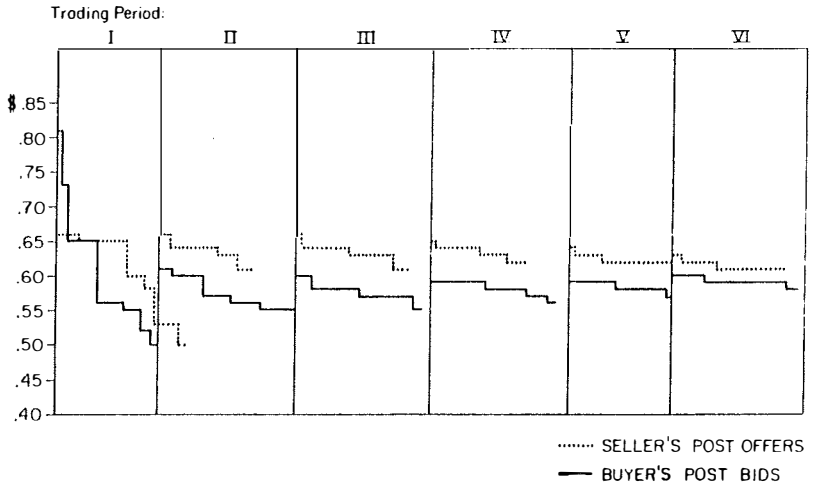


FIGURE 8

WILLIAMS' RESULTS:

CUMULATIVE DISTRIBUTION OF TRADES WITH MULTIUNIT INCENTIVES*

The figure represents for each price p, the volume of trades which took place at a price $p \geq p^*$.

Source: Charles R. Plott and Vernon L. Smith. "An Experimental Examination of Two Exchange Institutions." Review of Economic Studies 45 (February 1978):135

This suggests that one of the major features of the posted institution is that the "power" of the nonposting side is somehow eliminated. From an intuitive point of view one can see that when facing posted prices, abstinence from purchases (sales) is less likely to be met by more favorable terms because once the price is posted it cannot be changed until after the buying period is over. "Counterspeculation" as present in one sided oral auctions is absent under posted prices.

IV. MONOPOLY

Two different types of monopoly experiments have been conducted. The first and possibly the most relevant case for industrial organization theorists is the case of a single seller with a variable supply. The second case is one in which a fixed supply is to be auctioned or otherwise completely sold according to some type of competitive bidding process.

A. Variable Supply

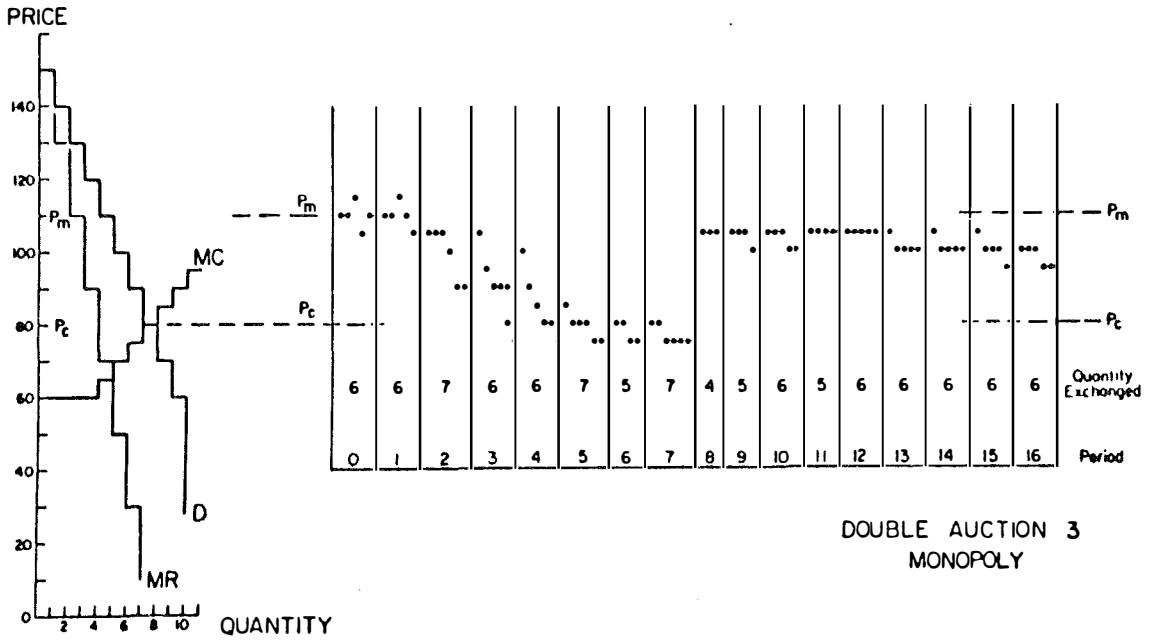
The difference in market performance under oral auctions as opposed to posted prices when there are several sellers leads naturally to an inquiry about the case of a single seller. Monopoly experiments under both institutions (Smith 1981) provide a dramatic demonstration of the importance of both industrial structure and the market institutional environment in determining market performance.

Monopoly can definitely cause prices to diverge from the

competitive equilibrium. However, when the market is organized as an oral double auction, the monopoly model itself does not do so well. There is a strong tendency for prices to erode away from the monopoly equilibrium price. On occasion, in Smith's experiments the prices actually approached the competitive equilibrium. The data are sufficiently mixed and the number of observations are so small that we cannot determine which model, the monopoly model or the pure competitive model, will be the easiest to modify to capture the behavior for monopolized oral double auctions. Figure 9 reproduces the time series from a particularly interesting experiment which demonstrates the difficulty with making any general statement about the comparative accuracy of the models. Prices start high near the monopoly price, erode to the competitive equilibrium, return to the high levels, and begin to erode again. This interesting behavior seems to be attributable to the buyers who have considerable power under this institution. Perhaps by "counterspeculation" they tend to withhold purchases and force prices down when facing a monopolist in this arena. Exactly what coordinates this action is unknown (these buyers cannot communicate except through bids and offers) but, as will be shown below, certain institutions seem to prevent it and therefore help the monopolist.

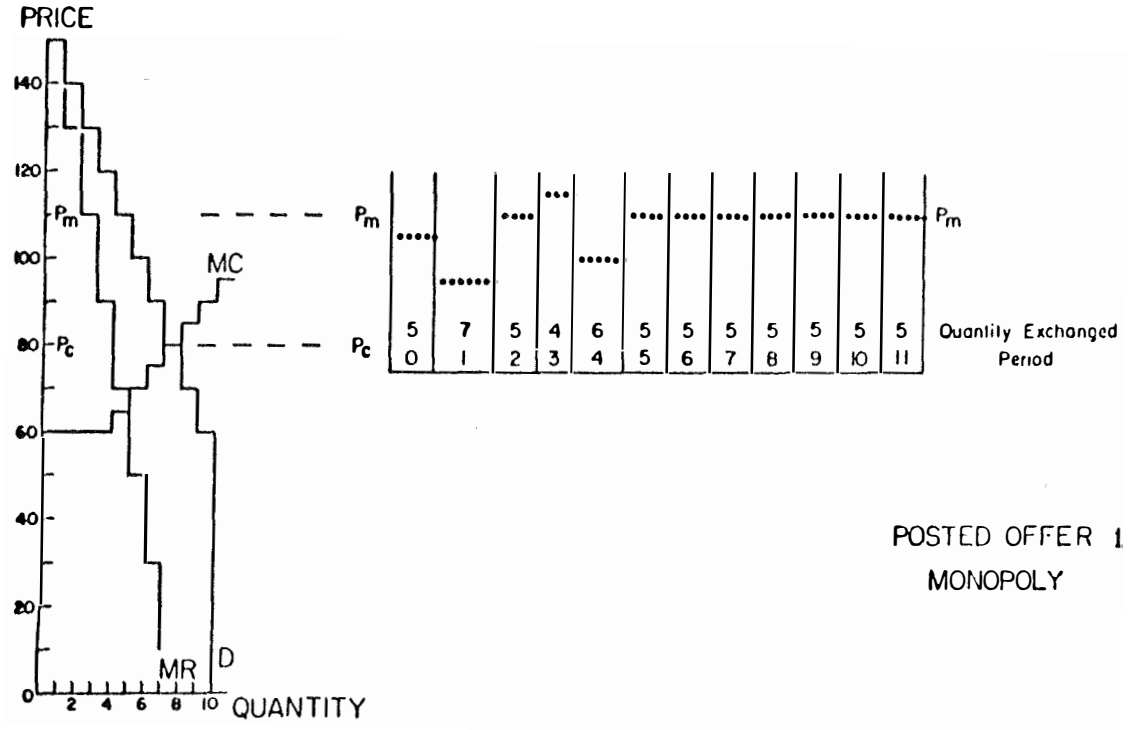
In contrast, when the market institutions are posted prices, a different picture emerges for the case of monopoly. With posted prices a monopolist behaves almost exactly as the monopoly theory asserts. The results of one experiment are in Figure 10. The monopolist adjusts prices to measure demand. The measurements are accurate because under the

FIGURE 9



Source: Vernon L. Smith. "An Empirical Study of Decentralized Institutions of Monopoly Restraint." In Essays in Contemporary Fields of Economics, edited by George Horwich and James Quirk. West Lafayette, Indiana: Purdue University Press, 1981.

FIGURE 10



Source: Vernon L. Smith. "An Empirical Study of Decentralized Institutions of Monopoly Restraint." In Essays in Contemporary Fields of Economics, edited by George Horwich and James Quirk. West Lafayette, Indiana: Purdue University Press, 1981.

posted prices the buyers do not "counterspeculate" and thus tend to reveal the accurate demand at each price. The monopolist ascertains the profit at each price, sets price at that level and then leaves it there. Compared to the oral auction the posted offer market is very mechanical. These data suggest that where monopolists have the power to determine the market institutions, a self-interest calculation would lead to some variant of a posted structure.

B. Fixed Supply

Industrial organization theory has traditionally been focused on the case of variable supply. Such focus is understandable because if the supply is fixed, the efficiency issues derived from the monopolist's behavior are almost nonexistant. Unless of course the monopolist can price discriminate, the behavior of a monopolized market with a fixed supply, which must be sold during a given market period, is exactly like that of a competitive market. Nevertheless the fixed supply case is of independent interest both as one critical step (marketing the supply) in a two step (determining supply) monopoly decision process and because fixed supplies (or resource demands) and the resulting competitive bidding markets are frequently involved in governmental decisions in which supply (or demand or procurement) quantity decisions are made by a political process.

The first sealed-bid experiments with many bidders were conducted by Smith (1976a). These experiments were motivated by a controversy about the United States Treasury market bonds. The Treasury uses a sealed-bid discriminative auction and critics of the

Treasury believed that a sealed-bid one-price auction would generate more money. A more recent problem regarding methods of allocating the right to land at four of the nation's busiest airports again focused research on the properties of these two different types of auctions (Grether, Isaac, and Plott 1981).

Smith used a methodology in which lotteries were auctioned. Belovicz (1979) using this same methodology explored extensively the principal hypothesis which emerged from Smith that the relative revenue-generating capabilities of the two auction institutions depended critically upon the magnitude of excess demand. The results emerging from that study are mixed.

The methodology was changed in Miller and Plott (forthcoming) and in Cox, Smith, and Walker (1981) to one in which the personal value of the object was known with certainty but the value to other bidders was unknown. In the former study bidders could purchase more than one unit, and aggregate demand was stationary for many periods (but subject to an occasional shift). Individual demands were rotated in a manner which preserved aggregate demand but changed each individual demand each period. In the latter, bidders could purchase only one unit, each period values were generated randomly, and only the discriminative auction was studied.

Both of these studies provide support for Nash equilibrium bidding models when there are several (three or four) bidders. That is an equilibrium identified as one in which each individual is optimizing given the actions of every other individual. The Miller-Plott study suggests that the relative revenue-generating capabilities

of the two types of auctions depend upon demand elasticity with discriminative auctions generating more revenue when demand is relatively inelastic and one-price auctions generating more revenue when demand is relatively elastic. In part this is due to the weight of "disequilibrium" auctions. After convergence takes place, they generate about the same revenue. These results are replicated in the study by Grether, Isaac, and Plott (1981).

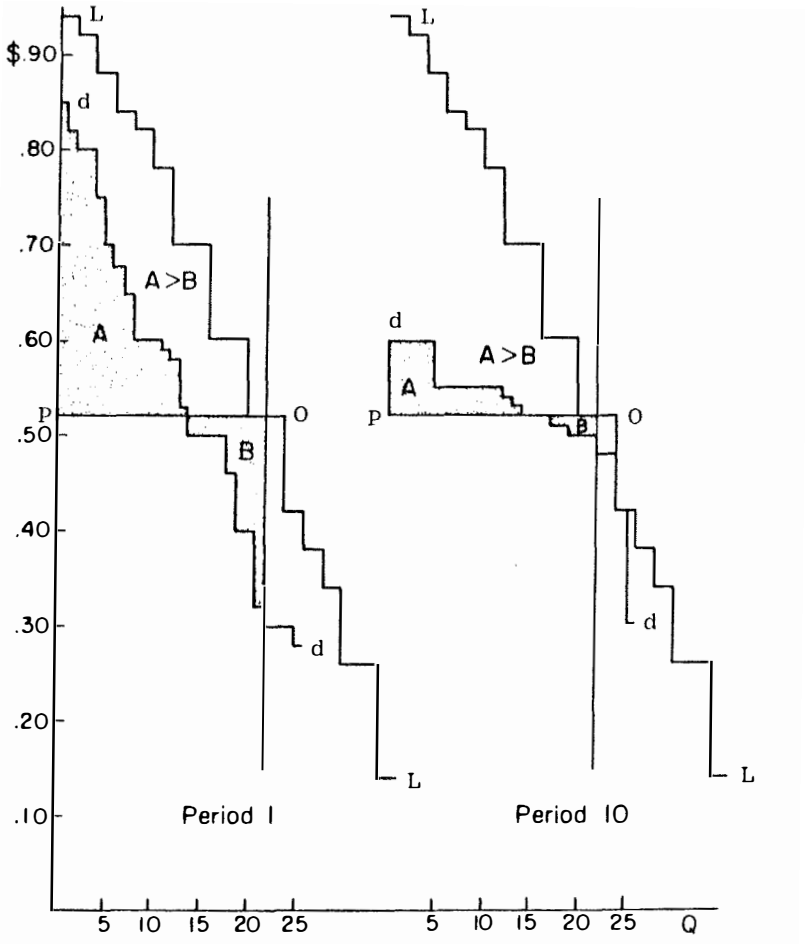
Figure 11 taken from Miller and Plott (forthcoming) illustrates the point. The limit price function is the curve LOL. The Nash equilibrium bidding curve is the line POL for the discriminative auction and it is LOL for the one price auction when there is some uncertainty. The actual bids for the first period under a discriminative auction are as shown by dd. Under one price auctions the distribution of bids is about the same for the first period. Under the one price auction the distribution of bids approaches the limit price function LOL after several periods so the price is P. The distribution of actual bids under the discriminative auction in the tenth period is shown. Since the area A is greater than the area B, the revenue under the discriminative auction is greater this period.

V. OLIGOPOLY

A polar case of cartel theory is monopoly so in a sense the results of a perfectly functioning cartel were reviewed in the previous section. A principal conclusion was that the performance of a monopoly (perfect cartel) market is substantially affected by the marketing institutions. Because this result carries over so

FIGURE 11

DEMAND AND REVEALED DEMAND IN A DISCRIMINATIVE AUCTION



Source: Miller, Gary and Plott, Charles R. "Revenue Generating Properties of Sealed-Bid Auctions: An Experimental Analysis of One-Price and Discriminative Processes." In Research in Experimental Economics vol. 2, edited by V. L. Smith. Greenwich, Conn.: JAI Press (forthcoming).

strongly to the case of "imperfect" cartels, the review is organized according to the market institutions as opposed to other industrial structural variables such as number of agents in the market, the size of agents, or demand elasticity.

A. Oral Auction Markets

Within oral auction markets two types of situations have been studied: an "obvious" harmony of interest and explicit conspiracy. Market participants almost always recognize a harmony of interest and this recognition can be identified in the market signals which occur almost constantly in oral double auctions. After a contract, when the market is open for bids or offers, the bidding will sometimes start with a clearly unacceptable bid or offer (e.g., a one cent bid or something far below any previously accepted price or an offer from two to ten times higher than any previously accepted price). Such bids (offers) are often followed by similar bids (offers) from other buyers (sellers) who are indicating a willingness to keep offers low (high). When this happens the other side of the market tends not to be passive. Such "outrageous" terms are frequently answered by equally ridiculous terms from the other side which is indicating that it too has available that strategy. Even when there is no answer, the terms of such high bids or offers are not accepted as the other side simply waits (counterspeculates). Competition slowly works the terms into the previously accepted range. Signals such as these never seem to work in the double auction institution or if they do the effectiveness is not immediately obvious.

In some experiments a harmony of interest is easily recognizable. In studies by Miller, Plott, and Smith (1977), Williams (1973) and Hoffman and Plott (1981), the markets had two speculators who could purchase units of an asset in one period (period A) and sell these in the next period (period B). These two individuals were the only agents who had the ability to buy units and carry them forward. They had a clear interest in maintaining a low price in period A and a high price in period B. In spite of this recognizable interest and the fact that only two agents had such powers, the market behavior is modeled well by an intertemporal competitive equilibrium.

The point is made somewhat more forcefully in Plott and Uhl (1981). In these markets four middlemen had the capacity to buy in one market in which they were the only buyers and sell in a physically separated market in which they were the only sellers. Unlike the speculation experiments referenced above in which all participants heard all bids, offers, and contracts in all markets, in the Plott and Uhl markets the initial sellers were one group of people who saw the action in the primary market and the final purchases were a different group of people who saw only the action in the secondary market. Both the harmony of interest and the collective power of the middlemen was obvious (but explicit conspiracy was not possible since they were never allowed to speak directly to each other). Nevertheless, the competitive model fits the data closely.[5]

In two studies focal points were given the opportunity to operate as collusive devices. In Isaac and Plott (1981b) and in

Smith and Williams (1981) price ceilings (floors) were imposed slightly above (below) the equilibrium. A theory is sometimes advanced (Scherer 1970, pp. 51-54) that such controls act as a focal point and thereby coordinate a tacit collusion. In the oral double auction markets reported in these studies there is absolutely no support at all that nonbinding controls operate that way. If anything the opposite is true with nonbinding ceiling (floor) operating to lower (increase) prices.

Private, preperiod meetings by one side of the market were studied as a facilitating practice under the double oral auction institution by Isaac and Plott (1981a). Four sellers (buyers) were allowed to talk freely between periods while the buyers (sellers) left the room to get the next period's demand (cost) functions. No side payments or profit sharing was allowed and discussions of such schemes were prohibited.

The study asked the following questions. Do traders discuss collusion when given the opportunity? Can the traders formulate some sort of agreement? Once formulated, do they stick to it? Can the consequences of the conspiracy be detected in the industrial conduct?

The answer to the first two questions is yes. These traders discussed conspiracy almost immediately and they had no difficulty in articulating an agreement. The answers to the second two are not without qualification. Data in Figure 12 provide a comparison with the oral double auction when no collusion is present (the first three experiments), with those in which there is a seller's conspiracy (the fourth and fifth) and a buyer's conspiracy (the sixth and seventh).

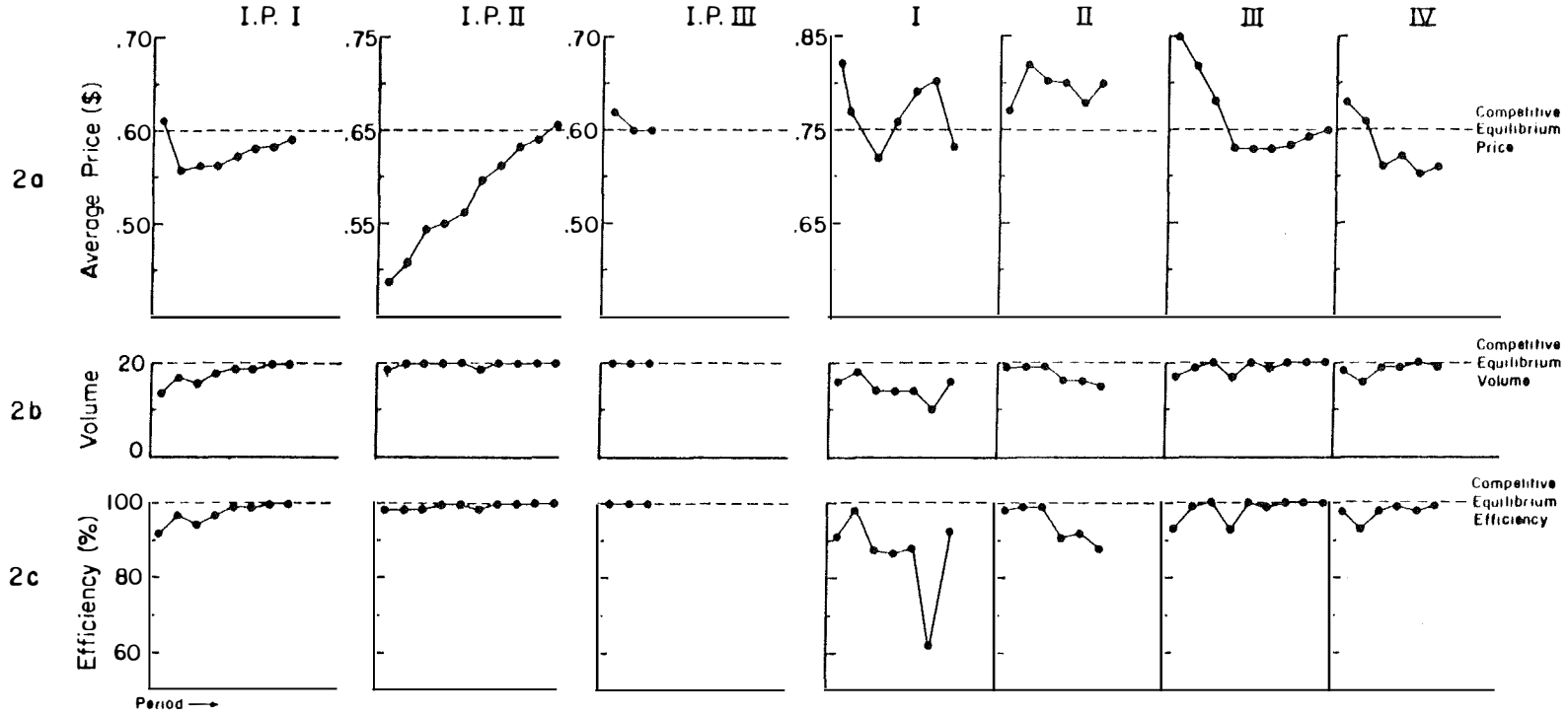
The top charts are the average prices each period. The middle charts are the per period volumes, and the bottom charts are the efficiencies.

In order to see the effects, it is important to notice the near monotone convergence of all three measures in the first three nonconspiratorial markets. Prices, volume, and efficiency. all three move monotonically to the competitive equilibrium levels. This does not happen in the conspiracy markets. In each of the four experiments with conspiracy, with the possible exception of experiment III, at least one of these measures exhibits some erratic behavior in the sense of a "pronounced" movement away from equilibrium. In this sense the conspiracy might be detectable from market data, but experiment III indicates the difficulty. Notice in experiment III there is a strong tendency toward the competitive levels even though there is an active conspiracy.

Figure 13 will help explain what is happening. Shown there is the sequence of bids, offers, and contracts from experiment III. This experiment involved the dramatic reduction in prices in period 4 as a result of a successful buyer's conspiracy.

> Some general discussion began after period 3. Note that, unlike period 3, the buyers in period 4 did not rush to accept high seller offers. In period 3, five of the first six trades were offers between 83 cents and 88 cents. In period 4, no offers were accepted until they reached 73 cents. In period 5, the tenth bid was at 72 cents. Between periods 5 and 6 the sellers agreed to try to hold the price at 71 cents. In period 6, the first twenty-seven bids were all either at 70 cents or 71 cents, with several intervening offers at 72 cents ignored. The twenty-eighth bid broke the agreement, and there were ten immediate trades at 72 cents. [Isaac and Plott, 1981a]

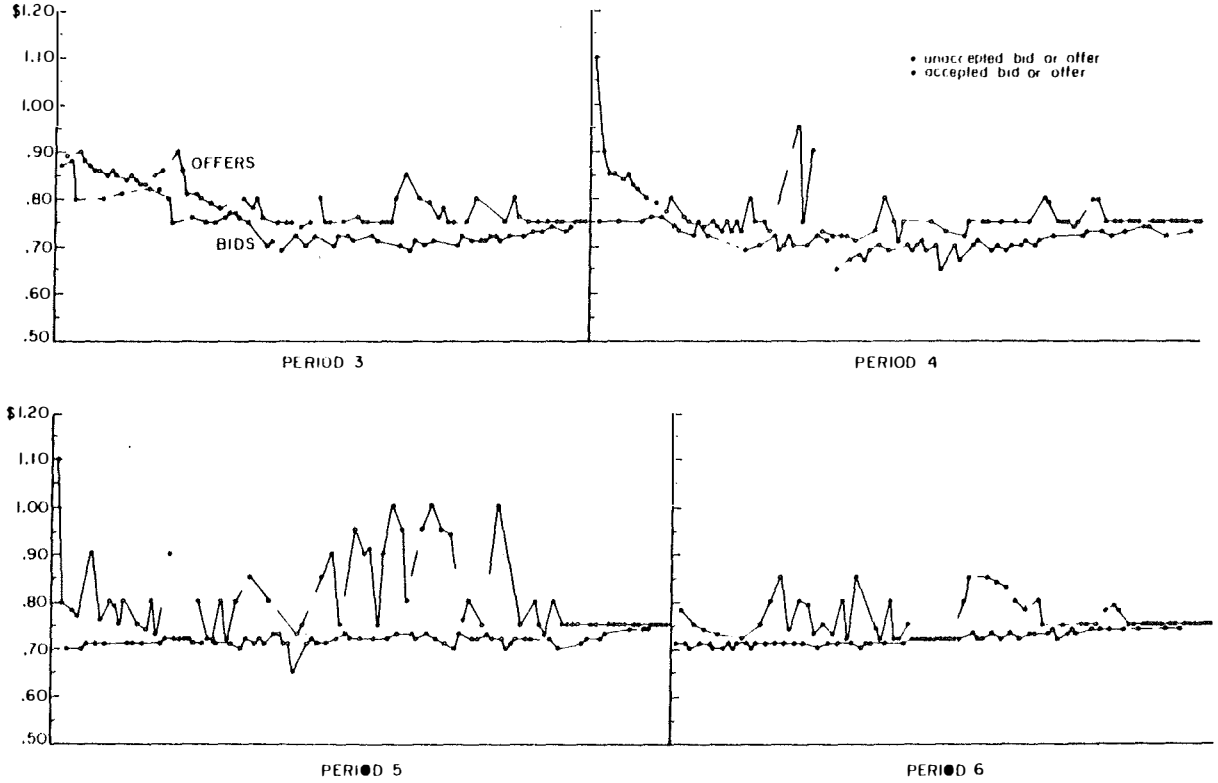
Of particular interest in this context are the high offers in period 5. These are interpreted as signals by sellers as an attempt to get other sellers to hold out. Frequently, however, they are made by sellers



AVERAGE PRICE, VOLUME, AND EFFICIENCY PER PERIOD

FIGURE 12

Source: R. Mark Isaac and Plott, Charles R. "The Opportunity for Conspiracy in Restraint of Trade: An Experimental Study," Journal of Economic Behavior and Organization 2, 1981, p. 10.



EXPERIMENT III PERIODS 3,4,5 AND 6
ALL BIDS AND OFFERS

FIGURE 13

Source: R. Mark Isaac and Plott, Charles R. "The Opportunity for Conspiracy in Restraint of Trade: An Experimental Study." Journal of Economic Behavior and Organization 2, 1981a, p. 20.

who have already sold and now have only high cost units which they do not expect to sell. The cost of signaling to them is low. Nevertheless, the fact that the nonconspirators are not simply passive is obvious.

The difficulty these conspirators have in substantially affecting market conduct seems to be related to the market institutional environment. As the Smith results reviewed above demonstrate, even a perfect conspiracy (monopoly) has difficulty in the double auction when one adds this property of auction markets to the fact that oligopolists can have difficulty in achieving coordination even under the most favorable conditions. Perhaps it is not surprising that the industrial structure used in the Isaac and Plott experiments (four buyers and four sellers) would make successful conspiracy difficult.

B. Privately Negotiated Prices

The only oligopoly markets studied within a market institutional environment in which all prices are privately negotiated are those in the Grether and Plott (1981) study referenced above. In these markets demand was relatively inelastic. The supply condition was one of excess capacity at a constant cost over the relevant ranges. The market contained several similarly sized buyers, two large sellers and two very small sellers. No entry was possible. All contracts were negotiated and executed privately by telephone.

In these markets each buyer and seller was located in a private office. Buyers had the phone numbers of sellers but not other buyers, and sellers had the phone numbers of buyers and not other sellers. Thus there was no possibility of conspiracy. In addition, phone calls were privately monitored through a master switchboard in a secretarial

pool as a further control. Subjects were told that side payments or discussions of side payments in any form (e.g. physical threats) were prohibited and that if any were detected the experiment would be terminated immediately.

In all other respects these markets were similar to those conducted under oral auction institutions. The time periods were longer (ten to fifteen minutes). As might be expected the volume in a telephone market moves slower because of the time involved with dialing, negotiating, etc.

Results typical of these experiments are shown in Figure 7 above. Variance in price is high at first but begins to shrink over time. Prices, as can be seen, hang slightly above the competitive equilibrium. Nevertheless, the market behavior is still more closely approximated by the competitive equilibrium model than any other "standard" theory.

C. Posted Prices

The posted price institution has been used in almost all oligopoly experiments. The practice was (perhaps inadvertantly) introduced by Hoggatt (1959) and by Fouraker and Siegel (1963). In the Fouraker and Siegel experiments each subject seller was given a profit table indicating profits as a function of own price and the competitor's price. Hoggatt used a mathematical demand function to determine revenues. In both cases the sellers, during a period, chose only a single price and the decision was irrevocable. Since a fixed revenue function or profit function was provided, the procedures

implicitly assume that buyers do not counterspeculate and therefore behave "passively" as under the posted price institution. Thus, the results seem to most appropriately be interpreted within that classification.

Two different demand structures were used in these early experiments. In one series of experiments Fouraker and Siegel used a homogeneous product in the sense that a price above a competitors resulted in a small loss. This reflects a primary interest of the experimenters in the Bertrand model of price determination. On the other hand, Hoggatt used individual demand functions which responded negatively to lowered competitive prices but volume for the high price competitor did not adjust discontinuously to zero. This reflects an interest in Cournot behavior. Fouraker and Siegel also conducted a series of experiments in which subjects each chose a quantity. With the total quantity known the experimenter would choose a price according to a predetermined demand schedule. All subjects then sold their chosen quantity at this price. The discussion below reviews the homogeneous case first.

In the Fouraker and Siegel design each competitor is given the profit table shown as Figure 14 which is held constant for the duration of several periods. Use of a profit table implies that the market demand function is known with certainty (unlike experiments discussed above). Prices above a competitor's price result in no sales and a small loss. Cost conditions are such that zero profits were earned at the competitive equilibrium as shown. (In a feature added by G. L. Murphy, referenced below, price levels below this

FIGURE 14

FOURAKER AND SIEGEL PROFIT TABLE

Price Bid	Profit When I have the Lower Price	Profit When I am Tied for Low Price	Loss When I Have the Higher Price
0.5	.13	.00	—
1.0	.35	.11	−.25
1.5	.53	.20	−.25
2.0	.67	.27	−.25
2.5	.77	.32	−.25
3.0	.83	.35	−.25
3.5	.85	.36	−.25
4.0	.83	.35	−.25
4.5	.77	.32	−.25
5.0	—	.27	−.25

Source: Murphy, James L., "Effects of the Threat of Losses on Duopoly Bargaining," Quarterly Journal of Economics 80 (May 1966):308.

involved a loss for all agents.) The economic interpretation would be one of no rents, and one consequence of this lack of "producer surplus" is that prices must necessarily approach the competitive equilibrium from above. The major treatment variable in the basic economic conditions category was the symmetry of the payoff functions, thus implying something about similarity of costs (for the homogenous product case the interpretation would be that all costs are constant at zero). Market structures were primarily duopolies but triopolies were also studied.

The primarily institutional variable aside from the posted price, involved the amount of knowledge available to agents. Under the Fouraker and Siegel complete information condition, the public information was that all agents knew all past choices and profits of all other agents. In the incomplete information condition, the public information was that profits were unknown and an agent only knew whether his price was higher or lower than the competitor's.

If one uses as the market price the lowest price in the market (the price at which all trades take place) then Fouraker and Siegel discovered a strong tendency for prices to converge toward the competitive equilibrium. By the fourteenth period the competitive equilibrium price prevailed in eleven of seventeen markets and was at the neighboring price (the price nearest the competitive equilibrium) in the case of incomplete information and even the remaining price was closer to the competitive equilibrium than to the joint maximum.

The complete information markets were characterized by a higher variance in behavior. Six of these markets were at the

competitive equilibrium by the fourteenth period. Three more were at the neighboring price. Four were exactly midway between the competitive price and the joint maximum and the other four were either at the joint maximum (two) or at the neighboring price (two). The additional information provided in this market setting tended to facilitate collusive behavior.

Fouraker and Siegel also examined triopoly. All of the eleven markets operating under incomplete information converged by the fourteenth period to the competitive equilibrium. All but one of the ten markets operating under complete information converged to the competitive equilibrium also. Thus, in these experiments the number of sellers was an important variable given complete information.

In a study by Murphy (1966) a similar decay process was observed in duopolies operating under the incomplete information condition. In general, however, he found the decay process to be slower with prices tending to hang somewhat higher above the competitive equilibrium than did Fouraker and Siegel. By the fourteenth period thirteen of seventeen duopolies were closer to the competitive equilibrium than the joint maximum. The Murphy experiments continued ten periods beyond the fourteenth period where the Fouraker/Siegel experiments stopped. At the end of the twenty-fourth period, eleven of the seventeen were closer to the competitive equilibrium than the joint maximum and five were exactly at the joint maximum. The variance across periods within experiments decreased. Thus markets either converged to the joint maximum or the competitive equilibrium

given more time with the additional time also adding to the tendency of the former.

The Murphy experiments involved three changes from the Fouraker and Siegel experiments. More price choices were available. Prices below the competitive equilibrium were possible with loses resulting in prices in that range and, of course the experimenter and subject pools differed. Murphy conducted only incomplete information markets with his own payoff charts. He concluded, by comparing the rate of cooperation with Fouraker and Siegel, that the threat of losses accounts for the higher rate. This conclusion is somewhat premature without a controlled experiment using the Fouraker and Siegel payoffs along with the Murphy payoff in the same subject pool and design. Rates of cooperation may well differ slightly from subject pool to subject pool and that might account for the differences with Fouraker and Siegel. Convergence to the joint maximum was not monotone. Instead, almost all of the duopolies experienced the competitive decay at first and then after several periods, prices began to drift upwards for those that ultimately converged to the joint maximum.

Presumably this "cooperative" phenomenon in duopolists operating under these conditions is facilitated by many trials and experience. The latter was explored extensively by Stoecker (1980) within the same parametric environment as Murphy but with complete information. Rather than many periods of a single market, Stoecker allowed individuals to obtain experience from many markets of ten periods each. Thirty-seven out of fifty duopoly markets managed substantial

cooperation (at or near the joint maximum). None of the remainder exhibited the property of the oral double auction of monotone convergence to the competitive equilibrium. Jumps of price were common.

The Stoecker experiments provide new insights into the nature and possibility of tacit collusion. Nineteen of the thirty-seven markets which attained the coordinated equilibrium near the joint maximum did so with no signals or "learning." It occurred with the first price choice with both competitors choosing the maximum and for the most part the systems stayed there. The behavior was prevalent among duopolists with previous experience. Thus, in this context, in which the harmony of interest could be clearly ascertained with no room for ambiguity or confusion, some duopolies needed no means of communicating intentions at all. Tacit collusion occurred immediately. For a subset (eighteen) of these fifty duopolies the joint maximum was not the individual maximum given equal prices. Of these, thirteen achieved stable equilibrium near the joint maximum and of the thirteen there were four which attained the equilibrium with the first move. Since these duopolists had twenty prices to choose from, it would be difficult to ascribe these coordinated actions to chance.

In Fouraker and Siegel and in Stoecker both of the basic economic conditions of profit function symmetry (Stoecker studied two different types of asymmetry) and the market structure (two, three, and five agent markets) were examined. Symmetry results in high market prices. Presumably this is because coordination is easier--the actions of the other agents can be more clearly understood and there can be no

disagreement over the joint strategies. If both are to charge the same price, a unique Pareto optimum exists. An increase in the number of firms almost always results in a convergence of price to levels near the competitive equilibrium. However, a slight upward bias relative to the competitive equilibrium even when the number of firms is "large," appears to be part of the general properties of the posted price institution.

Fouraker and Siegel conducted another series of experiments which can be interpreted as a case of nonhomogeneous products. In these markets, sellers each determined a quantity interpreted as the number of units to be offered for sale. After all decisions were collected by the experimenter, market price was determined by evaluating a fixed market demand function at the total quantity offered. Profits of each agent were determined by multiplying price by the agent's volume.

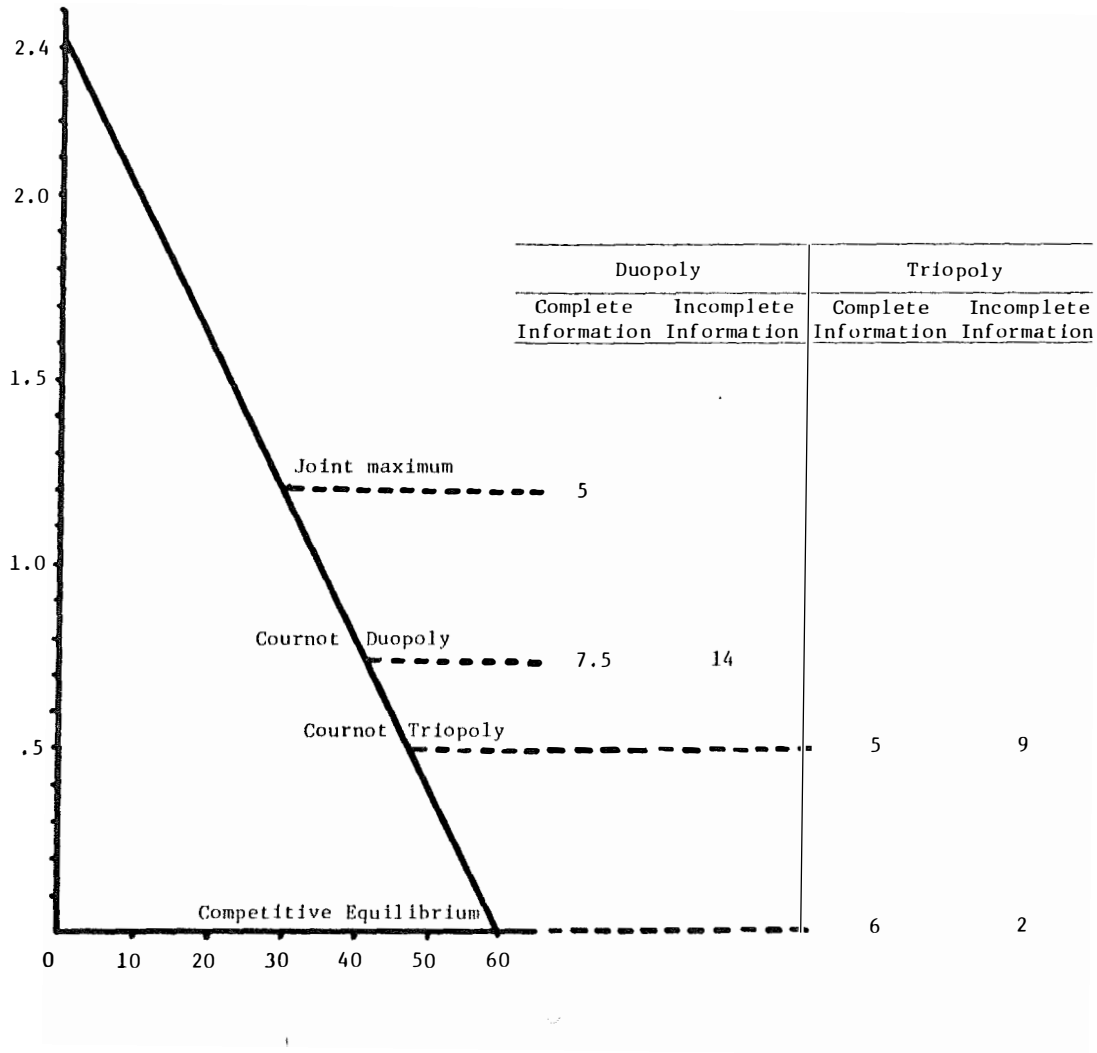
The results at the fourteenth period are summarized in Figure 15. Each market is categorized according to the model which most accurately predicts total market volume. As can be seen, the accuracy of the joint maximization or cartel model decreases with an increase in number of agents and also a reduction of information about the other agents' actions. Interestingly, the Cournot model as opposed to the competitive model seems to be most accurate in this "nonhomogeneous commodity" case. In the previous experiments the two models could not be given independent interpretations. Here they can and the Cournot model picks up much of the data. Whether this is the natural "upward bias" of the posted prices or an actual manifestation

of the Nash equilibrium principle is still an open question.

The work of Friedman (1963, 1969, 1970), Hoggatt (1959, 1967) and Dolbear, et al. (1968) has extended the posted price research in several directions. In these markets, products are in a formal sense no longer homogeneous. Recall, in the Fouraker and Siegel setting, prices higher than a competitor's result in a loss to the competitor with the higher price. Presumably this reflects the idea that competition with the highest price makes no sales and to the extent that costs were incurred, must suffer a loss. In the experiments to be discussed now the competitor with the highest price can still make some profit but not as much as would be the case if the price were equal to or below the other(s). As a result of this difference in market conditions the information conditions can be altered. Perfect information means that all profit functions and past price choices are known. Incomplete information means that all past prices (or quantities, as appropriate) are known but only an agent's own profit functions are known.

The findings are best represented in the recent book by Friedman and Hoggatt (1980) which describes the results of several oligopolistic markets under varying parametric information conditions and subject experience. Relative to other experiments these are exceptionally complicated because subjects made production decisions and inventory decisions along with price decisions. Subjects gained experience as in Stoecker by participating in a series of different markets over a long period of time. In addition to more refined models of individual decisions, two basic market models are compared:

FIGURE 15


2.4
2.0
1.5
1.0
.5
0
10
20
30
40
50
60
Joint maximum
Cournot Duopoly
Cournot Triopoly
Competitive Equilibrium
Duopoly
Triopoly
Complete Information
Incomplete Information
Complete Information
Incomplete Information
5
7.5
14
5
9
6
2

the joint maximum model and the Cournot equilibrium. The competitive equilibriums where price equals marginal cost are not examined. Of course, the Cournot equilibrium prices are above these prices.

Hoggatt and Friedman devote much effort to developing a model of individual behavior. The model developed, which has considerable support, assumes the individual develops estimates of the other agent's pricing decisions by an extrapolation of previous decisions. The individual then optimizes against that estimate. The resulting market equilibriums are reinforcing in a statistical sense. Cournot behavior in this sense is a good first approximation of individual behavior when tacit collusion is absent.

If the markets are characterized by perfect information and symmetric profit functions, the joint maximum is a good predictor for markets with up to four sellers. For the market with six sellers, prices dropped substantially to the Cournot equilibrium or just above it. If symmetry is dropped or if perfect information is dropped,[6] the number of sellers becomes a very important treatment variable in that an increase in the number destroys the accuracy of the joint maximum model. In the duopoly markets, significant (but less than perfect) cooperation occurs but, with an increase in the number of firms, it vanishes almost completely and the Cournot model is very accurate by comparison.

Friedman and Hoggatt conjecture what Stoecker convincingly demonstrates that experience makes a difference. "New and inexperienced faces" can cause market prices to deteriorate.

Hoggatt, Friedman, and Gill (1976) and Friedman and Hoggatt

(1980) provide the only attempts to model the signaling phenomenon. In part, signals are viewed as attention getting devices. Most of the work is an attempt to identify a signal as something distinct buried in the masses of data of the ordinary searching and competing price decisions. Within the posted price institution high or low prices have an immediate effect on profits so, as one might expect, signals occur rarely, relative to other decisions. Signals are identified as a type of "pulse" in which an abrupt change of behavior occurs for a brief period (a sudden large price increase or decrease) followed by a return to the original levels. Friedman and Hoggatt have attempted to develop models which will relate this activity to overall price changes and/or price levels. As of this writing they have a reasonable characterization of the phenomenon but feel it happens so infrequently in their data that the implications cannot be ascertained.

Thus, for the posted price institution a pattern is emerging. The institution seems to foster higher prices in general. Furthermore, under appropriate basic economic conditions and market structures, it can foster tacit collusion in the sense that the joint maximizing model is an accurate predictor of pricing patterns.

If the market institutions are the posted price as opposed to the oral double auction and the industrial structure is duopoly, a completely different picture of conspiracy emerges. Friedman (1967, 1970) studied posted prices of duopolies with asymmetric payoff functions. Perfect information existed in the sense that each competitor knew all previous price choices and payoffs (up to a scalar transformation on occasion). Competitors were allowed to transmit two written messages

before privately making a price decision. These messages were made in sequence with the same individual initiating contact for each of up to twenty-five periods (although most were from six to fourteen). In his data collusive agreements were attained in over 75 percent of all decisions made and of the collusive agreements 75 percent were Pareto optimal relative to the pair (no side payments were allowed). The ability to make such agreements increases with experience. Once a collusive agreement has been attained and successfully implemented, the probability of another successful agreement is .96.

Conspiracy does have implications for market conduct. Perhaps this is no surprise for those who have observed industry for years but these studies demonstrate the truth of the proposition for those who have not had the benefit of such observation or believe that the "competitive drive to defect" is so strong that collusion is impossible. However, the implications in terms of conduct cannot be divorced from both industrial structure and the market institutional environment.

D. Markets with Advance Notification and Price Protection

The recent actions taken by the Federal Trade Commission[7] have drawn attention to the market institution in the antiknock compound industry.[8] Industrial practices assure customers of a thirty-day advance notice of price changes (increases). Prices are quoted in terms of delivered prices with the same price prevailing regardless of transportation costs. In addition, contracts typically include a "price protection" clause which guarantees (i) that the seller will sell to no one at a price

less than the price quoted the buyer and (ii) the seller will meet any lower price in the market or release the buyer from the contract.

The industry structure is characterized by two large sellers of equal size (approximately 35 percent of the market each) and two small sellers of about equal size. A long-run declining demand (due to a reduction in lead use in gasoline) and existing excess capacity discourages entry. Eight large buyers account for about 60 percent of the sales and many very small buyers account for the rest.

Grether and Plott (1981) have explored markets with these properties. Each agent was assigned an office. Sellers were able to post prices by means of a digital electronic display system such that price announcements were made known immediately to all market agents. Orders were placed through the telephone system. Price increases required advance notice and all transactions were made at advertised prices (the buyer protection clause which precludes discounts). The industrial structure was as described above with the market demand and supply functions as shown in Figure 16.

The major conclusion of this study is that these practices when combined with the industrial structure cause prices to be above those that would otherwise exist. Figure 16 gives average prices during each of seventeen trading periods. Market institutions were a simple telephone market during the first twelve periods. As can be seen, the prices begin to decay toward the competitive equilibrium. The practices were imposed for periods 13 through 16. As can be seen, prices jump immediately to near those which exist at the Cournot equilibrium. When the practices were removed (periods 16 and 17) prices immediately fell. These data are representative of the pattern of findings from ten experimental markets.

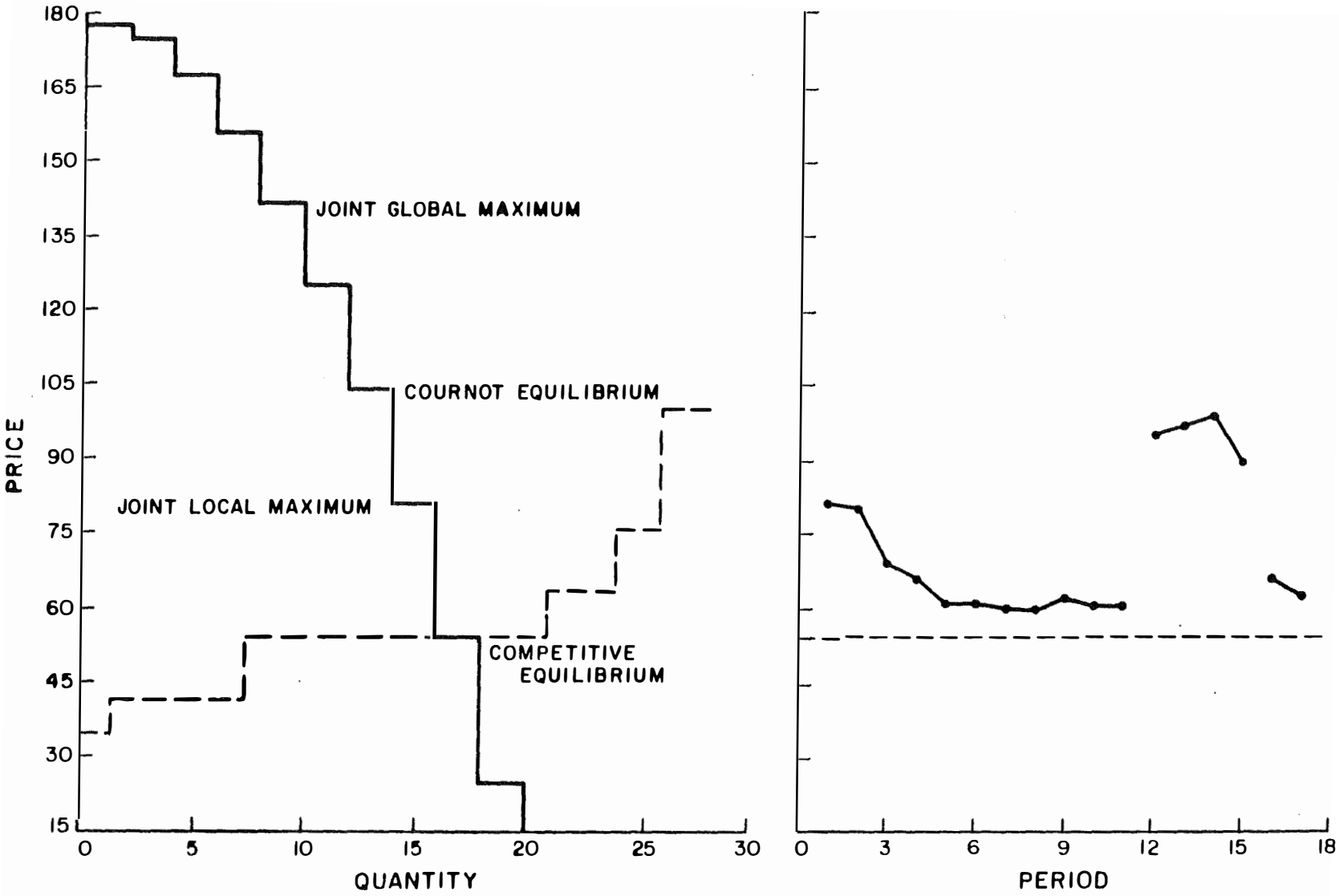


FIGURE 16

PARAMETERS AND AVERAGE PRICE PER PERIOD

The theoretical explanation of this phenomenon has some support. Advance notice given sufficiently in advance of the deadline for advance notification provides a signal to other sellers. If the notice involves a price sufficiently far in the future, it induces no current business loss. Only a single price is involved so the signal is uncomplicated with minimal dimensions over which disagreement can occur. Other sellers know that if they do not increase prices before the deadline, the original firm will rescind the proposed price increase. Thus other sellers do not have the option of "underselling" and acquiring a larger market share. The Nash strategy for such firms is simply to match the proposed price if a uniform industry price at the higher level will increase the firm's profits and do nothing otherwise. On the downside, due to the homogenous nature of the product, if not the buyer's protection, price cuts will be matched, so the incentive to cut prices depends upon the anticipated share of demand increase due to lower price levels. This model predicts that prices will certainly be at Cournot levels if not higher.

These institutions seem to have an effect on buyers similar to the posted price institutions. Buyers do not anticipate discounts because the institutions prevent them. Furthermore, since any price concessions must be offered to all, buyers can see that price concessions can be costly to the seller and thus have less expectation of winning them. As a result, the buyers seem to have less "counterspeculation" than in, say, the telephone markets alone. Thus these institutions appear to remove one source of buyer pressure for reduced prices while at the same time easing the problem of price coordination for the seller and eliminating the advantages of price cuts.

VI. DEFENSE OF EXPERIMENTS

Many of the studies reviewed above were designed and executed to answer reasonably specific questions related primarily to basic science. Sometimes applied scientists dismiss the experimental results and methods as being irrelevant and inapplicable. Needless to say, most questions cannot be answered by applying experimental methods. The theme of this section is on the art of posing questions which can.

The relevance of experimental methods rests on the proposition that laboratory markets are "real" markets in the sense that principles of economics apply there as well as elsewhere. Real people pursue real profits within the context of real rules. The simplicity of laboratory markets in comparison with naturally occurring markets must not be confused with questions about their reality as markets.[9]

If the reality of laboratory markets as markets is accepted, then the art of posing questions rests on an ability to make the study of simple special cases relevant to an understanding of the complex. General theories and models by definition apply to all special cases. Therefore, general theories and models should be expected to work in the special cases of laboratory markets. As models fail to capture what is observed in the special cases, they can be modified or rejected in light of experience. The relevance of experimental methods is thereby established.

Several different research strategies are apparent in the research reviewed in this paper but five will be identified here.

1. Theory Rejection. A model may be so poor at capturing observed behavior that it may be best to consider it no further or use it

even if no alternative model is available. The original experiments by Smith could be viewed as a potential basis for rejecting the ideas of demand and supply. If the model had not been at all accurate when applied to a simple market designed explicitly to give the model its "best chance" then it could be rejected. However, the model worked and as a result the original experiments were essentially ignored by the economics profession. Those who had a strong belief in principles of demand and supply said the results were "obvious." Critics of demand and supply dismissed the results saying that the markets were "rigged" so that demand and supply would work. When the approach is one of "model rejection," negative results, instead of positive results, are "interesting."

2. Theory Competition. In most cases competing models exist and existing data are not an adequate basis for rejecting one in favor of the other. The idea, then, is to create simple laboratory markets which are special cases of markets in which the models are generally applied. The experiments will, hopefully, indicate which is more accurate in the simple cases. While relative accuracy in a simple case does not prove that the model will continue to be relatively accurate when applied to the complex case, it does provide some experiences with the models. More importantly, it places the burden of proof squarely on those who continue to advocate the "losing" model to establish why the model they prefer would do relatively poorly in simple cases but relatively accurately in the complex. Presumably by applying additional theory and more complicated experiments, the credibility of their belief could be examined.

3. Model Robustness. We have seen that changes in the market institutional environment can change market performance. These facts were discovered as experimenters inquired about the accuracy of the competitive model under alternative institutional regimes. These were checks on the robustness of the model under institutional perturbations. Similarly, some studies have checked the robustness of the model under parametric perturbations such as number of competitors, demand elasticity, etc. Even though no formal theory exists (or any theory at all) about the influence of these factors, it is only natural to check. Then, once an important variable is found which was not anticipated by existing theory, the data from the experiments serve as a motivation for the development of extensions of the theory to cover the new facts. The influence of the posted price is a good example. No formal theory exists yet which completely explains the properties of this institution.

4. Measurement. When most scholars think of experiments, they have measurement in mind (e.g., what is the probability of tacit collusion? What is the speed of adjustment to equilibrium?). Laboratory experimental methods can be applied to these ends but none of the experiments above were predicated on the hypothesis that they were measuring numerical constants of nature. Questions of this nature would seem to require elaborate sampling procedures and explicit definitions of the populations to which the measurement is to be applied. The studies above all involved hypotheses about relative behavior as opposed to numerical constants.

5. Simulation. Another popular preconception about the function of experiments is simulation. In circumstances in which a policy is going to be imposed on a social system, simulation objectives involve an attempt to recreate the situation on a smaller scale in order to provide decisionmakers with some experience with how the situation might evolve.

If there is no theory to indicate which variables are important, the complexity of the small situation must mirror the complexity of the large as closely as is possible. Furthermore, without theory to unify the observations, the experiment must be conducted enough times to assure the "statistical validity" of any asserted pattern in the results. Thus theory, even in the case of simulation, serves importantly to simplify the experimental process. The more that accepted theory can be invoked, the less the experimental process needs to "mirror" the natural analog. The tendency of scholars to reject experimental methods as irrelevant may be because they are fundamentally interested in simulation while being unaware of the role of theory on the one hand and being very aware of the complexities of the situation (and the impossibility of recreating it) on the other hand.

The arguments above are straightforward, but it is easy to be pulled off track. Sometimes scholars use the term "real world" to refer to nonlaboratory processes and the term "artificial market" or "simulated market" to refer to laboratory markets. Such language invites criticism by failing to acknowledge the argument above about laboratory markets being real markets. In addition, the language

suggests that the primary test of relevance for laboratory market results is how closely the laboratory market approximates some naturally occurring market thus implying that the purpose is simulation. This test neglects the fact that one of the primary modes of learning is by model rejection. The laboratory environments provide an arena within which the relative accuracy of competing general theories can be evaluated and the poorer models rejected. Recall, general theories and models of markets must apply to all special cases independently of how those special cases compare with some other complicated special case which could itself be the result of several accidents of history. In essence, the test denies the relevance of a study of special cases and, if applied rigorously, it would reflect as negatively on experimental methods of physical sciences as it would on experimental economics.

The problem of relevance can surface in many different forms. In the remaining paragraphs four of the most common sources of skepticism will be discussed.

The first argument is a claim that "real" businessmen do not behave as do the subjects in these experiments. Stated like this the argument is not a criticism of experimental methods, it is a hypothesis about behavior in different subject pools and is thus a call for more experiments (with businessmen subjects). Similarly, arguments that the monetary amounts involved were too little (or too much) are simply demands for more experiments. The fact of the matter is, however, that a variety of subjects and payment levels have been used. The Hong and Plott (1977) study, for example, used employed

adults. To date, no subject pool differences have been reported.

The next three arguments derive from the fact that naturally occurring phenomena are inherently more complex than are laboratory processes. The first argument is that the laboratory environment is artificial. Exactly why is not articulated but with this argument the word is used many times and preferably loudly. It probably results from a gestalt view that there are so many important variables that they cannot be enumerated and that they interact in ways that are necessarily precluded in the laboratory.

This argument, notice, is not an argument against experimental methods in economics, it is an argument against experimental methods in general. The physical scientists must deal with it and so must the economists. Since the assertion cannot be falsified, the only answer lies in experimental work that has been helpful in generating successful models and points of view regarding more complex processes. As applied researchers find the data from experiments useful in shaping their own hypotheses and beliefs, this argument becomes less important.

The second argument is more specific in that it notes that naturally occurring processes do not occur in isolation. Industries are embedded in a larger social context. Businessmen have social relationships and friendships. They also know that their decisions while with one firm may affect their possibilities for changing firms.

This argument suggests that behavior in very complex environments may follow different laws than those which govern behavior in relatively simple situations. This is an excellent reason for being careful in any attempt to extrapolate behavior from a

laboratory to a complex industry. Notice, however, that it is not an argument against experimental methods. It is an argument for a particular type of experiment--one in which the complexity of the experimental environment is gradually increased similar to those of a given industry. If complications destroy the applicability of models, it might be possible to identify the precise complications which cause the problem and adjust the model accordingly. In a sense this program of increasing complexity is exactly how experiments are proceeding.

The final criticism also relies on the complexity of naturally occurring processes. How is one to know if the elasticity of demand and costs used in an experiment or if the particular market institution are those of the industry? If the results of the laboratory experiments are to be applied, shouldn't these be "right"? The answer to these types of criticisms are still more experiments under varying parameters. With a wide range of parameters explored, the question collapses into a judgment about parameters and not the experimental methods.

All of these arguments should make one cautious about extrapolating results generated from laboratory processes to naturally occurring processes. This type of extension must be dealt with artfully in the physical sciences as well as in economics. It is the most difficult task that any researcher faces. Experiments are simply an additional source of data and experience that one adds to other sources in making judgments about how the world works.

An easier task involves a somewhat negative approach placing the burden of proof on those who advocate theories. General theories apply in special cases. They should therefore be expected to work in

the simple laboratory environments and if they do not or if a competing theory works better, the burden of proof is on the advocate to tell us exactly why we should not judge him to be wrong. By adopting this point of view, researchers can use data from laboratory economics to reduce the size of the set of competing ideas.

VII. CLOSING REMARKS

Experimental studies demonstrate clearly that market institutions and practices can influence market performance. Variables traditionally classified as aspects of industrial structure are also of demonstrable importance. Furthermore, rather standard mathematical models are able to capture much of what can be observed behaviorally.

Three models do well in predicting market prices and quantity: the competitive equilibrium, the Cournot model, and the monopoly (joint maximization) model. Some tendency exists for the error of a model to be sensitive to structural and institutional variables (e.g., posted prices tend to be higher than prices under oral double auctions) but generally speaking, when a model applies, it does so with reasonable accuracy.

Interestingly enough, while experimental studies demonstrate that it is possible to model economic processes, they have also uncovered a problem in determining the conditions under which a model will be applicable. There is an interaction between variables which has not been fully explained. It is not the case that competitors are capable of collusive activity when merely recognizing a harmony of interests. It is also not the case that competitors cannot collude in the absence

of direct communication and the enforcement of agreements. Competitors seem to be willing to collude (so the rivalistic hypotheses[10] advanced in the early experimental studies can be safely dropped) but some industrial structures and market institutions make it easy while others make it almost impossible (in the sense that successful collusion has never been observed). Even a monopolist has difficulty within certain market institutions. Existing theory does not tell us exactly why this occurs, but the data suggest that one key is the behavior of the buyers. The data also suggest that market performance is very fragile (or "nonlinear") with respect to underlying structural and institutional variables and that "slight" changes (from four to two firms, or from price posting to some other institution) can switch a market from "competitive" to "collusive" or vice versa.

Existing results and methods lead naturally to questions of future results and applications. Research designed to study market institutions thought to have an influence on market behavior is certainly in the realm of feasibility. Modern theories are rich with implications about particular features of market institutions which might increase or decrease the tendency for competitive behavior. For example, almost all oligopoly theories imply that some form of potential retaliation is necessarily a feature of institutions which facilitate a reduction in competition. If the Stoecker results are replicable, then his design (posted price duopoly with experienced subjects) modified by allowing the same two competitors to meet only once and for only one period seems to provide a setting in which this common theoretical implication (the necessity for potential retaliation) can

be rejected. If individuals were observed colluding as one would expect from the Stoecker results but in addition without the existence of potential retaliations, then much rethinking of oligopoly theory would be necessary.

A better understanding of the role of structure must also be emphasized. Theories can differ about roles of excess capacity, symmetry in costs, lumpiness of demand, and the size distribution of buyers and sellers. Institutions which facilitate price competition under some market structures may actually decrease competition in others. Existing theories are frequently not worked out in sufficient parametric detail to suggest the points at which such "critical points" might exist. The reason for the lack of theoretical development is a low benefit/cost ratio for theorists who correctly suspect that field data appropriate for testing such a worked out theory will never exist. The possible existence of experimental data provides an incentive for theorists to work with structural models at a lower level of abstraction and in more operational terms.

Conditions of entry, advertising, and declining costs can all be incorporated into experiments. With the recent development of multiple market experiments it may be possible to undertake experiments with product quality and nonprice competition.

Many theories exist in the field of industrial organization which have not been reduced to a standard set of axioms or principles and are thus only tentatively accepted (at best) by much of the profession. For example, indirect indices of competition (share volatility, nature of price movements, etc.) must be relied upon in field situations

because marginal costs and the market demand function are simply not observable. Of course, in an experimental setting the degree of competition is easy to measure because all costs, prices, and other parameters are known. Thus, experimental markets can provide some experiences with the meaning and behavior of indirect indices under circumstances that are reasonably well understood. Similarly, the evolution of institutions themselves is of substantial importance.

What type of market institutional environment might one expect for a given industrial structure? The data suggest the nonneutrality of the marketing practices so one might expect that self-interested individuals who realize the relationships and have an opportunity to affect market institutions would do so. To the extent that market institutions are part of market conduct, industrial organization economists have a clear interest in this question. Perhaps the reason that this issue has not been addressed experimentally reflects the fact that the independent influence of institutions is only now being realized. No doubt this void will be filled as theory is is developed which will suggest what one should look for in and demand from an experimental environment.

No doubt the ultimate usefulness of experimental work will be determined by demonstrations that experiments provide insights about what one finds upon close examination of industries. Prosecutors and regulators must choose which cases to prosecute and what reliefs to pursue and frequently the choices must be based on very thin data and controversial economic theories. The facts which might falsify the theory are often impossible to obtain without undertaking the long

and expensive process of litigation. Experiments are an alternative, relatively inexpensive, and relatively quick source of data. How these data will be regarded by the courts is yet to be determined (Kirkwood 1981) but there seems to be no substantial difference between data from experimental markets and data from other types of experiments. The fact that experiments can always be rerun and the validity of claims checked, places severe constraints upon those who might enter such data as evidence in a court proceeding.

APPENDIX

The instructions below are typical of those used in the experiments reviewed. Both posted bid market and oral double auction organizations are included. These instructions are read by the experimenter. The incentive forms (Figure 2) are also distributed. The forms are also reproduced on the blackboard and completed by the experimenter as directed by the instructions and the example in the instructions.

INSTRUCTIONS

GENERAL

This is an experiment in the economics of market decision making. Various research foundations have provided funds for this research. The instructions are simple and if you follow them carefully and make good decisions you might earn a considerable amount of money which will be paid to you in cash.

In this experiment we are going to simulate a market in which some of you will be buyers and some of you will be sellers in a sequence of market days or trading periods. Attached to the instructions you will find a sheet, labeled Buyer or Seller, which describes the value to you of any decisions you might make. YOU ARE NOT TO REVEAL THIS INFORMATION TO ANYONE. It is your own private information.

SPECIFIC INSTRUCTIONS TO BUYERS

During each market period you are free to purchase from any seller or sellers as many units as you might want. For the first unit that you buy during a trading period you will receive the amount listed in row (1) marked 1st unit redemption value; if you buy a second unit you will receive the additional amount listed in row (5) marked 2nd unit redemption value; etc. The profits from each purchase (which are yours to keep) are computed by taking the difference between the redemption value and purchase price of the unit bought. Under no conditions may you buy a unit for a price which exceeds the redemption value. In addition to this profit you will receive a 5 cent commission for each purchase. That is

[your earnings =

(redemption value) - (purchase price) + 0.05 commission].

Suppose for example that you buy two units and that your redemption value for the first unit is $200 and for the second unit is $180. If you pay $150 for your first unit and $160 for the second unit, your earnings are:

$ earnings from 1st = 200 - 150 + 0.05 = 50.05

$ earnings from 2nd = 180 - 160 + 0.05 = 20.05

total $ earnings = 50.05 + 20.05 = 70.10

The blanks on the table will help you record your profits. The purchase price of the first unit you buy during the first period should be recorded on row (2) at the time of purchase. You should then record the profits on this purchase as directed on rows (3) and (4). At the end of the period record the total of profits and commissions on the

last row (41) on the page. Subsequent periods should be recorded similarly.

SPECIFIC INSTRUCTIONS TO SELLERS

During each market period you are free to sell to any buyer or buyers as many units as you might want. The first unit that you sell during a trading period you obtain at a cost of the amount listed on the attached sheet in the row (2) marked cost of 1st unit; if you sell a second unit you incur the cost listed in the row (6) marked cost of the 2nd unit; etc. The profits from each sale (which are yours to keep) are computed by taking the difference between the price at which you sold the unit and the cost of the unit. Under no conditions may you sell a unit at a price below the cost of the unit. In addition to this profit you will receive a 5 cent commission for each sale. That is

[your earnings =

(sale price of unit) - (cost of unit) + (0.05 commission)].

Your total profits and commissions for a trading period, which are yours to keep, are computed by adding up the profit and commissions on sales made during the trading period.

Suppose, for example, your cost of the 1st unit is $140 and your cost of the second unit is $160. For illustrative purposes we will consider only a two-unit case. If you sell the first unit at $200 and the second unit at $190, your earnings are:

$ earnings from 1st = 200 - 140 + 0.05 = 60.05

$ earnings from 2nd = 190 - 160 + 0.05 = 30.05

total $ earnings = 60.05 + 30.05 = 90.10

The blanks on the table will help you record your profits. The sale price of the first unit you sell during the 1st period should be recorded on row (1) at the time of sale. You should then record the profits on this sale as directed on rows (3) and (4). At the end of the period record the total of profits and commissions on the last row (41) on the page. Subsequent periods should be recorded similarly.

MARKET ORGANIZATION (Posted Bid Institutions)

The market for this commodity is organized as follows: we open the market for each trading day. Each buyer decides on a purchase price which he will write on one of the cards provided. The buyers will be given two minutes to submit their prices. The cards will be collected and the prices written on the blackboard. Sellers will then be free to make offers to sell whatever quantities they desire and to specify the buyer to whom they wish to sell. Offers will be made as follows: a seller will be chosen using random numbers, and will state the quantity he wishes to sell and the buyer to whom he wishes to sell. The buyer will then accept any part of the seller's offer by stating the quantity he wishes to buy. However, when a buyer posts a price, he must be prepared to buy at least one unit. If the first buyer will not purchase all units the seller wants to sell, the seller is free to choose a second buyer, and so on.

When the first seller has made all his contracts, another seller will be selected at random and he will make his desired purchases. The process will be continued until there are no offers to sell. This completes the trading day. We will reopen the market for

a new trading day by having buyers submit new prices and the process will be repeated. Except for the offers and their acceptance you are not to speak to any other subject. You are free to make as much profit as you can.

Are there any questions?

MARKET ORGANIZATION (Oral Double Auction)

The market for this commodity is organized as follows: we open the market for a trading period (a trading "day"). The period lasts for ___ minutes. Any buyer (seller) is free at any time during the period, to raise his hand and make a verbal bid (offer) to buy (sell) one unit of the commodity at a specified price. The bid (offer) must be higher (lower) than the outstanding bid (offer) should one exist. Any seller (buyer) is free at any time to accept or not accept the bid (offer) of any buyer (seller). If a bid (offer) is accepted a binding contract has been closed for a single unit and the buyer and seller will record the contract price to be included in their earnings. Any ties in bids or acceptances will be resolved by a random choice of buyer or seller. Except for the bids (offers) and their acceptance you are not to speak to any other subject. There are likely to be many bids and offers that are not accepted, but you are free to keep trying, and as a buyer or a seller you are free to make as much profit as you can.

Are there any questions?

FOOTNOTES

1. The single exception is an experiment reported in Smith (1981).

2. A possible example within the framework reviewed in this paper is explored in Cohen, Levine, and Plott (1978). The case is one in which the subjects in a committee experiment evidently thought they were to provide insights for marketing strategies and ignored the incentive system.

3. Notice that without a commission the marginal trades under the conditions of Figure 3 may not be made. There are no gains from an exchange of the third unit of one and three for example.

4. This study involved a slight variant of the oral double auction. Bids and offers were left open until accepted or changed. Thus the market institutions were similar to a double oral auction with limit orders and an open book.

5. In still another study (Plott and Wilde 1981) sellers as a group (four sellers) knew they could collectively increase demand in the same sense that physicians, automobile mechanics, and other professionals can influence demand. The data give no support at all for collusion models.

6. Information in Dolbear, et al. did not have a measurable effect. Subsequent experiments suggest that the payoffs used in this experiment were so small (five cents difference in profits between Cournot equilibrium and monopoly) that the influence of any variables would be hard to detect. Nevertheless, the data tend to be very close and just above the Cournot equilibrium and the qualitative influence of other variables is consistent with those of later studies.

7. The Federal Trade Commission complaint against Ethyl, DuPont, PPG and Nalco Chemical Company (Ethyl Corporation, et al. Docket No. 9128).

8. The product is added to gasoline by refiners to reduce knock and raise gasoline octane rating.

9. See Plott (1979) for a detailed discussion.

10. This hypothesis maintained that competitors will attempt to maximize relative profits thereby transforming the market into a zero sum game.

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